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A STUDY ON THE "FAST WALL" STABILITY AT RIO KEMPTVILLE OPEN-PIT TIN MINE EAST KEMPTVILLE, NOVA SCOTIA

FINAL REPORT BY:

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RÉSUMÉ

L'éxpansion verticale de la mine à ciel ouvert de East Kemptville durant les derniers 18 mois a débouché sur la nécessité d'optimiser le rendement et d'éviter l'exploitation dans des murs à pente raide, tout en gardant la sécurité.

L'excavation du perimètre Est de la fosse et la gradation des deux banquettes supérieures sont terminées. Notre analyse est fondée sur la cartographie structurale faite par le personnel de la mine dans la fosse principale et dans la zone "Baby."

On a divisé la fosse en 4 zones structurales qui correspondent effectivement aux 2 types de roches et aux 2 zones de minage. La face exposée du parement est formée de roches de plus en plus compétentes en allant en profondeur. On considère que dans la plupart des zones, le dimensionnement des pentes va se baser principalement sur la géométrie des banquettes.

Dans la circonstance d'une double banquette (24 m) et de largeur effective de 10 m, on recommande comme pentes suivant les cas:

(a) un angle de 56° pour les granites situés dans la fosse principale,
(b) un angle compris entre 50° et 56° pour les méta-sédiments situés dans la fosse principale, selon l'orientation du mur,
(c) un angle de 56° pour les granites de la zone "Baby," et finalement
(d) un angle compris entre 50° et 56° pour les méta-sédiments situés dans la zone "Baby," selon l'orientation du mur.

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ABSTRACT

Areal expansion of the East Kemptville Mine open pit over the past 18 months has led to the need to optimize ore recovery and minimize stripping through the development of steeper wall angles without a sacrifice of safety.

The preliminary measures of ditching the up slope eastern perimeter of the pit combined with the scaling of the crest of the upper two benches has been completed. The completion of the in pit structural mapping of the Main Pit and the Baby Zone by mine personnel has been the basis for this study.

The open pit has been divided in four basic structural areas corresponding to the two main rock types and the two mining areas. The exposed wall rocks are judged to be competent, with the degree of competency increasing with depth. In most areas, bench geometry will control the overall slope design.

Based on double benches (24 m) and effective berm widths of 10 m, the following interramp slope angles have been recommended:

a. for Main pit granites approximately 56°,
b. for Main pit metasediments approximately 50° to 56° depending on wall orientation,
c. for Baby Zone granites approximately 56°, and
d. for Baby Zone metasediments approximately 53° to 56° depending on wall orientation.

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I INTRODUCTION

I.1 Operating Environment

Rio Kemptville Tin Company operates the only producing tin mine and concentrator in North America at East Kemptville in southwestern Nova Scotia. This operation is also the world's lowest grade, hard rock, operating tin mine and currently mines to a cut-off grade of 0.140% Sn.

Rio Kemptville produces three concentrates: a tin concentrate grading >50% tin, a copper concentrate grading 20% copper, and a zinc concentrate grading <50% zinc.

The East Kemptville tin deposit is an example of a large tonnage (50 mT) low grade (0.200% Sn) greisen-hosted tin deposit. Tin occurs as cassiterite and is associated with a wide variety of other minerals including topaz, pyrite, chalcopyrite, sphalerite, arsenopyrite, and pyrrhotite. Tin grades are extremely erratic within the more sharply defined greisenised zones of the deposit.

The deposit is mined by open-pit methods at a strip ratio of approximately 1:1. A Marion M3 rotary blast-hole drill, drilling 251 mm diameter blast holes at 6.5 m centres, is the primary drilling machine used in the pit. Occasionally a contracted Ingersoll-Rand T4 drill is used to assist in blast-hole drilling. This machine drills 152 mm diameter holes at 4.0 m centres. Loading equipment consists of two 7.6 m^3 P&H 1900 series electric shovels and one 9.4 m^3 Clark loader. A fleet of 7 Terex 85T haul trucks completes the list of principal heavy mining equipment used in the pit.

I.2 Project Outline

The development of the 1989 and 1990 mining plans resulted in the need for a push back of the main pit east wall to the ultimate limit and early access to Baby Zone ore in the south. The ultimate pit of the day was based on higher tin prices, overall wall angles of 43°, and limited actual data in the economic model. By mid 1989, the current mining plan, declining tin prices, and an amended geological deposit model illustrated that ore recovery could be maximized and stripping minimized if safe but steeper wall angles could be developed. Visual examination of single bench faces illustrated bench face angles of 80° to 70° were quite common.

Piteau Associates of Vancouver were invited to prepare a proposal to geotechnically assess our current pit slopes. The Piteau proposal was to utilize structural data from the exploration adit and mine personnel to geotechnically log the 1989 diamond drill core and to set up an in pit mapping program to swiftly map then safely accessible bench faces. Historically, there have not been any detected or reported slope failures since mining began in September 1985. Piteau would analyze the data and recommend wall slope angles and berms and any remedial measures if necessary (Appendix 2).

The logging of the Baby Zone during the summer of 1990 and the commencement of overburden removal from the east wall area and Baby Zone in October 1990 put a new emphasis on increased pit wall slopes.

II WORK SUMMARY

In addition to the overburden removal in November and December, a 600 m long drainage ditch was installed around the east perimeter of the newly exposed Baby Zone. Upon completion of the overburden removal, two hydraulic excavators were contracted to scale the eastern crest of the 106 and 94 benches to prevent loose material from ravelling down on the crew and mining equipment.

In mid December 1990, Alan Stewart of Piteau Associates made a mine site visit to: (1) do a limited amount of pit wall mapping, (2) slope documentation, (3) inspect select 1989 drill core, (4) collect mapping data from the exploration adit, and (5) instruct mine personnel in geotechnical mapping procedures.

Evaluations of integrated electronic total station survey instruments to replace our aging E.D.M. Theodolite were completed over the period January to March 1991 (Appendix 3). An electronic total station with data collector would reduce the deficiencies of the exiting system, improve the speed and accuracy of data collection and computer data entry, and greatly facilitate the calculation of month-end measure volumes and pit wall stability measurements. A Wild-Leitz TC-1000 electronic tachy meter with a 2000 point recording module and a GIF 12 data recorder were purchased by the end of March 1991. After minor software changes, field data could be down loaded from the recording module to our computerized mine planning software. This unit has been in trouble-free operation for the past nine months.

As time permitted over the period June to November 1991, Jeff Smith of the Geology Department, carried out the pit mapping program as outlined by Piteau Associates (Appendix 4). A total of 156 mapping stations were established: 130 in the main pit and 26 in the Baby Zone. Mapping was not carried out in the main pit area on the 58 and 46 benches because of

(1) unsafe access and (2) faces covered by sluffed material from benches above.

By mid November the second half of the mapping data was forwarded to Piteau Associates to complete their final analysis. The final report "Rock Slope Stability and Design Assessment of the East Kemptville Mine is found in Appendix 1.

III SUMMARY OF ANALYSIS, CONCLUSIONS, AND RECOMMENDATIONS

A. Four basic structural areas corresponding to the two main rock types and the two mining areas were defined as:

1. Main Pit Granites
2. Main Pit Metasediments
3. Baby Zone Granites
4. Baby Zone Metasediments

B. Five point sets were recognized, of which three are considered to be continuous and well developed. No large scale regional faults were mapped; however, some faults and shear zones have been observed from the surface and adit mapping.

C. Based on select diamond drill core, it is expected that "the vast majority of the rocks....to be exposed in the pit walls will be competent, with the degree of competency increasing with depth."

D. Slope stability analyses were conducted for all kinematically possible as well as basic failure modes and general rock mass behaviour. Generally the principal kinematic controls are wedge and planar failures. These analyses assumed both rock types could occur on most of the ultimate pit wall orientations, and design criteria were established for the basic structural areas and their specific wall orientations. In most areas, bench geometry will control the overall slope design. (Appendix 1, Table II and Figure 3 illustrate the recommended design parameters.)

E. 1. Where structures will permit, bench face angles of up to 80° for single benches and 75° for double benches are possible.

2. Double benches (24 m) are recommended, although higher bench configuration may be utilized after trials on interim walls prove positive.

3. Utilizing double benches, the following interramp slope angles have been derived:

   a. for Main pit granites approximately 56°,
   b. for Main pit metasediments approximately 50° to 56° depending on wall orientation,
   c. for Baby Zone granites approximately 56°, and
   d. for Baby Zone metasediments approximately 53° to 56° depending on wall orientation.

4. Effective berm widths are 8 m and 10 m for 12 m and 24 m benches, respectively.

F. Reduction of blast damage to the rock mass by using control perimeter blasting and careful production blasting. The use of surface drainage ditches to direct water away from slopes, clearing berms, and scaling of faces and crests will minimize rock falls and damage to men and equipment. Prism monitoring to detect slope displacements will aid in design modifications.

G. The following on-going work will assist in updating the slope design:

1. on-going geologic structural mapping of faults, fault sets, and joint sets, as new faces are safely exposed,

2. geotechnical logging of any future diamond drill core before being split, and

3. documentation and back analyze of any slope failures combined with periodic visual inspection.

APPENDIX 1

ROCK SLOPE STABILITY AND DESIGN ASSESSMENT

PITEAU ASSOCIATES, DECEMBER 1991

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EAST KEMPTVILLE MINE

ROCK SLOPE STABILITY AND DESIGN ASSESSMENT

DECEMBER 1991

PITEAU ASSOCIATES ENGINEERING LTD.

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Fig. 2 Slope Geometry Parameters.
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1. INTRODUCTION

This report summarizes the investigation and analyses carried out to prepare preliminary open pit slope designs for the East Kemptville Mine. The terms of reference for the study were summarized in a letter proposal dated July 24, 1989 from Piteau Associates Engineering Ltd. (PAEL) to Mr. G. Smith of the Rio Kemptville Tin Corporation (RKTC). As stated in the terms of reference, RKTC was to carry out virtually all of the data collection, while PAEL was responsible for the analytical and slope design aspects.

A preliminary assessment of the slope angles for the East Wall of the Main Pit, and for the walls of the Baby Zone, was conducted by PAEL following receipt of the first portion of the structural mapping data on July 8, 1991. Results of this assessment were summarized in a letter report entitled "Preliminary Geotechnical Assessments for the East Wall of the Main Pit and the Baby Zone Final Walls" which was forwarded to Mr. C. McAleenan of RKTC on July 12, 1991. The geotechnical assessments carried out for this report were conducted after receiving the remainder of the data from the mine on November 22, 1991.

The engineering geology, structural geology, and rock competency of the site are summarized in Section 3. Slope stability analyses and the proposed slope design are presented in Section 4, and conclusions and recommendations are summarized in Section 5.

2. DESCRIPTION OF THE INVESTIGATION

2.1 FIELD INVESTIGATION

A preliminary site visit was conducted by Mr. A. Stewart of PAEL on July 3 and 4, 1989, prior to submitting a letter proposal. At this time Mr. Stewart reviewed the mine geology, demonstrated core logging and field mapping procedures to site personnel, and examined the site to obtain an appreciation of general rock mass conditions and geotechnical parameters. Copies of relevant plans, background information, etc. were obtained during this visit. The second site visit was conducted from December 10 to 13, 1990, during which time Mr. A. Stewart carried out a number of tasks, including: reviewing geotechnical core logging carried out by RKTC personnel; reviewing 1981 geologic structural mapping data obtained in exploration adits; conducting geologic structural mapping and slope documentation at selected, representative locations around the pit; reviewing general background geologic information; demonstrating geotechnical mapping techniques to mine personnel; reviewing blasting practices, etc.

2.2 OFFICE STUDIES

Geologic structural analyses and slope stability analyses were carried out on the geologic structural mapping data collected during the mapping program conducted by RKTC personnel, and on the 1981 mapping data contained on the plans of the underground workings. All geologic mapping data were processed and plotted on lower hemisphere equal area projections using a desktop computer. Statistical methods were used to define the basic geologic structural parameters, and to develop an appreciation of the nature and distribution of these features in the rock mass.

Based on the results of the structural analysis, and on a review of the current pit plan, the pit was divided into areas wherein the general rock type and geologic structure are expected to be similar (i.e. structural areas). In order to develop slope design criteria for a range of slope orientations, numerous design sectors were defined. Separate slope stability assessments were carried out for each design sector. Equal area projections were used to determine the kinematically possible failure modes which are likely to control slope design in each design sector. Mechanical stability analyses were carried out on all possible failure modes, and slope design configurations were developed for 12m high single benches and 24m high double benches. Based on a layout of the existing pit and a possible configuration for the ultimate pit, preliminary interramp slope angles were prepared and summarized on plan.

3. ENGINEERING GEOLOGY

A detailed report concerning the geology of the mine area has been prepared by Richardson, et. al. (see reference in Section 7). Information pertinent to the slope stability study has been extracted from this report, and is included in the discussion below. A general plan of the pit area is shown on Fig. 1.

3.1 REGIONAL SETTING

The East Kemptville Tin Mine is located in Yarmouth County in southwestern Nova Scotia, approximately 54 km northeast of Yarmouth. The tin deposit was discovered in July 1978, and mining of the deposit commenced in 1984.

The mine is situated at an elevation of about 100m. Topography is somewhat hummocky and rolling, and vegetation is moderate to dense. Average annual precipitation in the area is approximately 1450mm (combined rainfall and equivalent snowfall).

The mine is located at the southwestern end of the South Mountain Batholith in granitic rocks referred to as the Davis Lake Pluton. The intrusion of the granodiorite pluton into the quartzites of the Cambro-Ordovician Meguma Group is expected to have occurred during the Late Devonian to Early Carboniferous period (i.e. approximately 370 million years ago). The contact between the two units trends approximately northeast.

3.2 BEDROCK LITHOLOGY

The main rock types of interest to this study are the metasediments of the Halifax Group, and the granitoid intrusives of the Davis Lake Pluton. The metasediments consist primarily of quartzites, graywackes and argillites. Rocks of the Davis Lake Pluton are primarily greisen and sericite altered granodiorites which have been intruded by smaller, discrete bodies of adamellite, aplite, and pegmatite.

Tin mineralization occurs primarily in the form of cassiterite and is located within the altered granodiorites. Mineralization is greatest immediately below the northwest dipping contact between the two units, with the degree of mineralization decreasing to the east, and also with depth. The main ore zone is approximately 100m thick, 1500m long, and 500m wide.

3.3 STRUCTURAL GEOLOGY

A rational slope stability analysis and slope design requires that the mine area be subdivided into areas of approximately similar geologic structural characteristics. The engineering behaviour of slope forming materials can be expected to differ in areas of the rock mass which have different geologic structural characteristics. Hence, extrapolation of stability analysis results and slope design criteria is only valid within areas of the rock mass having similar geologic structural characteristics. Such areas are called structural areas.

At the East Kemptville Mine, four basic structural areas, corresponding to the two main rock types and the two mining areas (i.e. the Main Pit and the Baby Zone), were defined as follows:

i) Main Pit Granites
ii) Main Pit Metasediments
iii) Baby Zone Granites
iv) Baby Zone Metasediments

The most important consideration in determining the similarity, or lack thereof, between geological structural populations within a structural area, or between structural areas, is the orientation of the discontinuities. Other parameters, such as continuity (joint extent or size), roughness, infilling, etc. were considered in evaluating the engineering properties and nature of the joint sets, but were not used for designation of structural areas. Lower hemisphere equal area projections were used to define the peak or average orientation for each main discontinuity set mapped in each structural area.

3.3.1 Joints

Attitudes of the main joint sets are summarized in Table I and shown on lower hemisphere equal area projections in Appendix A. Throughout the mine area, the joint sets are seen as reasonably well defined clusters. In some cases, it is reasonable to represent each joint set by a single peak orientation. However, other joint sets are diffuse enough that they may be more readily represented by two or three different peaks. In such cases, the joint set is represented by a number of subsets (e.g. Joint Set S1A, Joint Set S1B, etc.).

As summarized in Table I, up to five joint sets were recognized in the mine area, three of which are considered to be particularly continuous and well developed. The joint sets mapped at the mine site are described as follows:

i) Joint Set 1

Joints of Joint Set 1 are present in both of the main rock units and are well developed in all areas of the mine. In all cases, these joints strike approximately east-west, and dip steeply to the south (see Photo 1). They tend to be very continuous, often extending over a number of benches, and appear to be relatively young, tending to cut through some of the other joint sets.

ii) Joint Set 2

Joints of Joint Set 2 are also well developed in both rock types and all mine areas. These joints are characterized by a northwest/southeast strike, and a steep northeast or southwest dip. As for joints of Joint Set 1, these joints often extend for a number of benches, cutting across most of the other joint sets (see Photo 2).

Photo 1: Various joint sets in granite on the eastern side of the pit.

Photo 2. Joint Set 2 on eastern wall. Note multi-bench continuity of structures.

iii) Joint Set 3

Joints of Joint Set 3 are found in both granites and metasediments of the Main Pit, but were only mapped in the granites in the Baby Zone (see Photo 1). These joints typically strike north/south and dip steeply to the east or west. They tend to be less well developed and slightly less continuous than most of the other joint sets.

iv) Joint Set 4

Joints of Joint Set 4 are strongly developed in all rock types and in all areas of the mine. Typically, these joints are characterized by a northeast/southwest strike, and a steep northwest/southeast dip (see Photo 3). However, several moderately dipping joints of this set were mapped in the metasediments along the northwest wall, with dips ranging from 45° up to 90° to the southeast. While these joints do not appear to be as continuous as some of the other joint sets (i.e. such as Joint Sets 1 and 2), bench faces in the metasediments on the northwest wall of the main pit often break back to these structures (see Photo 4).

v) Joint Set 5

Joints of Joint Set 5 were only mapped in the granites of the Main Pit, and in the sediments of the Baby Zone. This set is typically characterized by a northeast/southwest strike, and a near horizontal to shallow dip to the northwest (see Photo 1).

3.3.2 Faults

No large scale regional faults (i.e. major structures) were mapped on the pit walls. However, based on a limited amount of data from the underground adit mapping and the surface mapping (which has subsequently been included with the joint mapping data illustrated in Appendix A and summarized on Table I), some faults and shear zones have been observed.

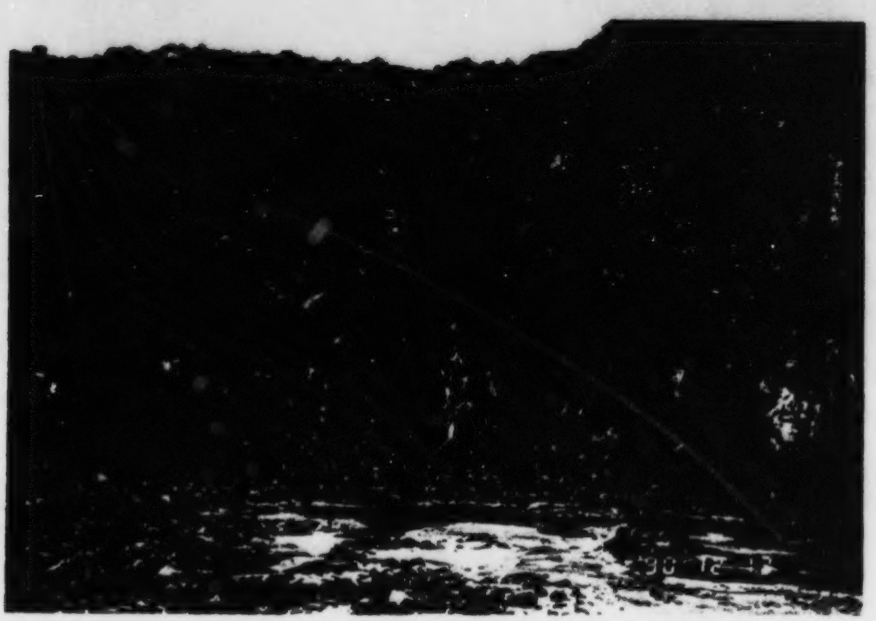

Photo 3. Typical discontinuity of Joint Set 4.

Photo 4. Joint of Joint Set 4 dipping at 45°, forming a bench face in the metasediments on the northwest wall of the pit.

Most of the faults are subparallel to joints of Joint Sets 1, 2 and 4, the most strongly developed joint sets mapped in the pit.

3.4 ROCK COMPETENCY

In addition to the structural geology aspects described above, a rational prediction of the likely behaviour of a rock mass also requires an assessment of the general physical and mechanical properties of the rock mass. Such parameters as susceptibility to mechanical deterioration, alteration and strength characteristics may be of key importance in evaluating rock mass behaviour.

Based on geotechnical core logs from five BQ diamond drillholes and on a review of a limited amount of representative diamond drill core, a brief assessment of rock quality was undertaken. The results of this assessment indicate that the average Rock Quality Designation (RQD) for the metasediments and the granite is good to very good. In this regard, 215m of metasedimentary core had an average RQD of 80% (i.e. good), while the average RQD for 612m of granitic core was 96% (i.e. very good). As would be expected, the near surface rock is slightly more broken than the rock at depth, having experienced the effects of a certain amount of near surface weathering typical of most rock masses. However, with the exception of very limited lengths of core (i.e. usually <5m), even the most broken near surface bedrock typically has an RQD of between 60% and 70% (i.e. fair). Thus, it is anticipated that the vast majority of the rocks that will be exposed on the pit walls will be competent, with the degree of competency increasing with depth. As indicated in the drill core, the granite is expected to be slightly more competent than the metasediments.

3.4.1 Unconfined Compressive Strength of Intact Rock

Based on the results of field index testing and the laboratory uniaxial compressive strength tests conducted by W.A. Crosby in 1986, it can be seen that the rock in the pit area is strong and hard, having an estimated unconfined compressive strength (UCS) of at least 8,000 psi (i.e. an estimated hardness of R4[*]), with most of the granite having a UCS of at least 16,000 psi (i.e. an estimated hardness of R5).

The limited amount of near surface weathering that has occurred has only stained some of the joint surfaces and does not appear to have weakened the intact strength of either the metasediments or the granite.

3.4.2 Discontinuity Strength

Little is known concerning the shear strength of discontinuities within the rock mass. However, as most of the discontinuities that are likely to control the stability of the slope are steeply dipping (i.e. >70°), detailed assessments of discontinuity shear strength are considered unnecessary at this time. For purposes of stability analyses, discontinuities are assumed to have negligible cohesion and a friction angle of 30°. As most of the joints have a moderate degree of roughness, the assumed discontinuity strengths are considered to be conservative.

3.5 HYDROGEOLOGY

Very little recent information is available concerning the hydrogeology in the pit area, and no piezometers have been installed in the vicinity of the pit. However, in a July 1984 report prepared by Jacques Whitford & Associates Ltd.concerning tailings disposal at the time, it was reported that the dominant direction of regional groundwater flow appeared to be from the southeast to the northwest, with recharge taking place on the higher ground southeast of the mine. Groundwater levels were observed to be within a few metres of the ground surface. Groundwater was also expected to flow predominantly in joints, faults and shear zones, with about the upper 100m of bedrock (i.e. where weathering has resulted in increased fracturing) being more permeable than the bedrock at depth. As was observed on the pit wall, the contact between the metasediments and granite was expected to be a zone of increased permeability. The steeply dipping continuous nature of the discontinuities was expected to promote relatively steep flow paths and thus relatively short groundwater travel distances. Permeability of the upper 20m of metasediments was estimated to be about $5x10^{-7}$ m/s.

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[*] See Appendix B for a description of the relationship between hardness and unconfined compressive strength.

During the site visit in December 1990, it was observed that there was considerable seepage and ice buildup below about the 94m elevation on the southeast pit wall. It was also observed from the seepage and joint staining that most of the seepage was occurring on the near vertical joints that trend approximately perpendicular to the pit wall. Based on these observations and on the information contained in the Jacques Whitford report, it is anticipated that development of the pit will probably result in only local drawdown of the groundwater table, with the zone of drainage around the pit only extending a relatively short distance behind the face.

4. SLOPE STABILITY ANALYSES AND SLOPE DESIGN

Slope stability analyses involved investigating all kinematically possible failure modes (i.e. failure modes involving discrete blocks, formed by discontinuities, which are free to topple or slide into the excavation) which could lead to shallow failure of individual benches, and/or deep seated failure involving large sections of the overall slope. Consideration was also given to the performance of the existing slopes with respect to evaluation of basic failure modes and general rock mass behaviour.

4.1 BASIC SLOPE DESIGN CONSIDERATIONS

In rock slopes, instability may result from failure along structural discontinuities such as bedding, joints, geological contacts, faults, etc. (i.e. kinematic failures). In high slopes or slopes in relatively weak or altered rock, instability may also develop as a result of failure through intact rock or along a deep seated failure surface consisting of a combination of discontinuities and intact rock. In analyses of deep seated failure, an assessment of the rock mass strength is usually required.

When assessing failure mechanisms related to structural discontinuities, the most important factors are the orientation, geometry, and spatial distribution of discontinuities in the slope. It is also important to evaluate these discontinuities with respect to both the orientation and alternative possible angles of the proposed pit slope. It is following these basic principles that the slope stability analyses were carried out.

Slope control can basically be accomplished in two ways:

a) to design the slope so that no failures occur, or

b) to excavate the pit under controlled conditions and to design the slope with adequate access so that failures can be caught on berms and removed, if necessary.

The first solution is usually too conservative to be economically feasible. The second solution requires thorough consideration of the slope geometry so that failures are contained on berms and safe access is available to the berms to allow removal of collected debris, if required. This solution provides adequate safety at minimal cost, although special design or remedial measures may be required to ensure the stability of haulroads or critical installations on benches.

The parameters which govern the geometry of a slope are shown in Fig. 2. These parameters are primarily controlled by the strength and nature of the rock. Bench height should be selected to provide safe working slopes as well as an optimum interramp slope angle. It should be noted that, without affecting the slope angle, higher benches will allow wider berms for better protection and more reliable and easier access, if this is desirable, although the size of possible failures may increase.

Berm width should be controlled by the access required to the slope, as well as by the optimum width to accommodate failures. It must be accepted that, even with careful perimeter blasting techniques, some breakback may occur. In general, slopes should have berms wide enough to trap falling debris and, if and where desired, provide sufficient access for equipment to keep berms clean and effective as catchments.

By inclining the bench faces, blasting damage is reduced, and higher stresses are less likely to develop near the bench crests. Hence, tension cracks and overhangs are minimized. Avoiding these problems reduces the amount of rockfall and increases the safety of the slope.

4.2 ENGINEERING GEOLOGY AND DESIGN SECTORS ON THE PIT SLOPES

Rational slope stability analysis and slope design requires prediction of the geologic structural conditions which will occur on the pit walls. Such a prediction includes determining the distribution and location of lithologic units, major structures, etc. (i.e. Structural Area boundaries). At the East

Kemptville mine, the basic approach to preliminary slope design was to consider slopes in the various structural areas separately.

Not only must structural areas be considered for individual analysis; the overall orientation of the pit walls must also be considered. Different pit wall orientations may require different design considerations. Hence, it is usually necessary to define zones which contain one structural area and one general slope orientation. These zones are designated design sectors.

The assumed orientations for the final walls of the ultimate pit were based on the orientations of the existing pit walls. Slope stability assessments were conducted assuming both rock types could occur on most of the ultimate pit wall orientations (with the exception of the southeast wall), and slope design criteria were established for each rock type and wall orientation in both the Main Pit and the Baby Zone. Information relating to the pit wall orientations and related information for the possible design sectors is summarized in Table II and illustrated on Fig. 3.

4.3 ASSESSMENT OF POSSIBLE DEEP SEATED FAILURE MECHANISMS

A brief assessment was carried out to assess the possibility of deep-seated failure involving several benches, or even the whole slope. Failures of this nature may involve major throughgoing faults or other major discontinuities. In this regard, both individual structures and/or the average orientation of fault/discontinuity sets should be considered.

At the East Kemptville mine, no major structures were identified during the mapping. Faults and other continuous structures identified from the bench mapping conducted by RKTC are steep dipping and subparallel to Joint Sets 1, 2 and 4, with most of the structures oriented approximately perpendicular to the final walls (i.e. subparallel to Joint Sets 1 and 2). Based on this information, no kinematically possible large scale failures with a dip or apparent plunge as flat as the anticipated range of interramp slope angles appear to be possible.

Deep-seated failures may also develop through a complex interaction of minor and/or major structures to form a large continuous failure surface. In some cases, deep seated failure planes can, in part, develop by failure through intact rock bridges between discontinuities. Such failures are often precipitated by small slope readjustments and high stress concentrations at the toe of the slope, which tend to exceed the strength of the rock mass. This type of failure mechanism is particularly common in slopes where softer material at the toe of the slope, such as coal, potash, or schist bands, is squeezed out due to the load which is applied by the overlying strata.

For engineering purposes, the principal consideration in evaluating the compressive strength of the rock mass is to determine if there is any possibility of excessive deformation and, ultimately, rotational failure of the slope. This would be due to failure of the intact material, resulting from the weight of the overlying strata.

Based on the relatively high hardness and high compressive strength of the intact rocks in the pit, combined with the relatively low overall slope heights, the likelihood of time dependent strain and subsequent failure of the rock mass appears to be small. Hence, the possibility of deep seated rotational failure due to failure of the intact material involving the whole slope is low.

4.4 STABILITY ANALYSES AND ASSESSMENT OF KINEMATICALLY POSSIBLE FAILURES

4.4.1 Slope Design Based on Orientation of Geologic Structure

As discussed above, individual discontinuities or combinations of discontinuities may form discrete blocks which could result in failure of the slope or benches (i.e. kinematically possible failure modes). Because there are variations in intensity, orientation and dip of the discontinuity sets throughout the mine, the significance of one particular failure mode on the stability of a particular slope may be low. However, the combined significance of all possible failure modes, with respect to both the actual and predicted performance of the slope, may be high and should be evaluated to prepare a rational slope design.

From observations made at the mine, it appears many structures are continuous over more than one bench height. However, because of the generally steep nature of most structures in the mine area, it is unlikely that failure would develop over more than one bench height.

4.4.2 Determination of Kinematically Possible Failure Modes

Lower hemisphere equal area projections of planes representing the peak orientations of the various discontinuity sets in each possible design sector were used to define possible failure modes. Failure modes which are considered to be kinematically possible are illustrated on the equal area projections in Appendix C.

4.4.3 Mechanical Stability Analyses

Simple limit equilibrium stability analyses were carried out for each possible failure mode using computer techniques. Negligible cohesion and a friction angle of 30° were assumed for all discontinuities. These strength values are considered conservative.

To simplify the analyses, drained slopes were assumed, and a Factor of Safety greater than or equal to 1.2 was considered adequate for stability of dry (i.e. drained or dewatered) slopes. A Factor of Safety greater than 2.0 (assuming the dry condition) was considered adequate for stability of slopes subject to adverse groundwater conditions (i.e. undrained or fully saturated slopes).

4.4.4 Assessment of Possible Failures

With the exception of one design sector in the Baby Zone where no controlling failure modes are apparent, the principal kinematic controls are wedge and planar failures on benches. As shown in Table II, these potential failures vary in terms of their intensity or importance. That is, the relative degree of development of individual discontinuity sets or combinations of discontinuity sets which form potential failures, and therefore the likelihood of bench faces consistently breaking back to or forming along such failures, is variable. Based on the estimated intensity/importance of the principal kinematic controls summarized in Table II, and on engineering judgement, the apparent plunge or dip of potential failure modes considered to control stability of individual benches was selected (see Table II). For example, in Design Sector B317-S, the numerous planes of Joint Subset D4C with a peak dip of 73° are felt to control the stability of the benches. While the potential for plane failures on 47° dipping joints of the same general joint set (i.e. Subset D4D) is recognized, these flatter joints do not seem to be strongly enough developed to control the design of the bench. In this case, breakback along the flatter joints is only considered to be a local problem, unless overblasting results in opening and/or extension of these joints.

While it is not anticipated that toppling failure will control the design of any slopes, it is possible that slopes which are parallel to very steeply dipping discontinuity sets that dip into the slope may experience some toppling. For example, in Design Sector B317-G, the likelihood of toppling will depend on the exact orientation and spacing of the steep dipping joints of Joint Set 4.

In general, because most of the strongly developed kinematic controls are steeply dipping, it is unlikely that large deep seated failures could develop in the pit. Hence, in terms of design of interramp slopes, bench geometry will control the overall slope design in most areas.

4.4.5 Bench Breakback Analysis

To evaluate the behaviour of existing benches at the mine, a brief study of existing slope angles was carried out. Documentation of bench face angles was conducted by RKTC personnel during mapping of the existing pit. This information was combined with observations made by Mr. Stewart during his site visits.

Results of this brief assessment indicate that, in the absence of adversely oriented structures, most of the bench face angles in both the metasediments and the granodiorites are at least 75° (see Photo 5). However, on the northwest wall in the Main Pit metasediments (but not in the Baby Zone metasediments), somewhat flatter joints of Joint Set 4 often control the steepness of the bench face (see Photo 4).

Berms in most locations are relatively clean and free of rockfalls and ravelling debris.

4.5 INTERRAMP SLOPE DESIGN

As the possibility of deep seated failure involving multiple benches on large portions of the slope is low, slope design has been carried out by assessing possible bench failures and related bench geometries for the main rock units (i.e. metasediments and granites). Consideration was also given to the results of bench breakback, and observed bench face angles in similar materials in similar orientations.

A schematic pit plan for the East Kemptville mine is illustrated on Fig. 3. This schematic plan assumes 24m high double benches in both materials, and overall slope heights of up to 100m. Preliminary slope designs based on the general slope orientations shown on this plan are summarized in Table II and Fig. 3.

4.5.1 Bench Geometry

Based on an assessment of the engineering geology and the kinematic controls, and because of the advantages of achieving higher bench heights, both 12m and 24m high benches were evaluated in all design sectors.

Photo 5. Steep bench face above 106m safety berm in granite on southeast wall.

Design bench face angles were assumed to be 90°. In some design sectors, it is anticipated that, with careful controlled excavation, it should be possible to achieve effective bench face angles of at least 80° for 12m high single benches and 75° for 24m high double benches. However, where the apparent plunge or dip controlling slope design (determined from the kinematic analyses) is less than these values, the lesser value was selected as the design bench face angle.

As shown on Fig. 2, total berm width is defined as being the sum of the breakback of the bench crest (i.e. between vertical and the effective bench face angle) and the effective berm width required to provide access, contain small failures and rockfalls, etc. At the East Kemptville mine, recommended effective berm widths are 8m and 10m for 12m and 24m high benches, respectively. These berm widths, combined with the conservative design bench face angles described above, should be sufficient to allow for some breakback and provide for catchment without becoming so narrow as to be ineffective.

4.5.2 Interramp Slope Angles

Based on the assessments carried out and the bench geometries discussed above, the range of preliminary slope angles which appears feasible is summarized on the right hand side of Table II. As can be seen, steeper interramp slope angles can be achieved if 24m high double benches are utilized. However, increased care and caution with drilling, blasting and excavating must also be taken when increasing the bench height.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 PRELIMINARY SLOPE DESIGNS AND TRIAL SLOPES

Based on the results of the slope stability analyses summarized in Section 4 and on experience, it is concluded that, where the structure will allow, bench face angles of up to 80° for single benches, and 75° for double benches are possible. From observations made of existing slopes, it is recommended that double benches be utilized, although other bench configurations could be incorporated on a trial basis on interim walls before establishment of the ultimate slopes begins. It should be noted, however, that the geometrical constraints associated with higher bench heights (i.e. triple benches or higher) may result in flatter overall slope angles. Assuming double benches are utilized, it can be seen from Table II and Fig. 3 that:

- interramp slope angles in the Main Pit granites will be approximately 56°.

- interramp slope angles in the Main Pit metasediments will generally range from 50° to 56°, depending on wall orientation. The most adverse wall orientation in these rocks is where the wall is subparallel to the strike of Discontinuity Set 4, where a shallow dipping subset is well developed. In this case, an interramp slope angle as flat as 40° is indicated. Such wall orientations are only expected to exist over a small portion of the northwest wall. However, this should be further investigated during development of the pit.

- interramp slope angles in the Baby Zone granites will be approximately 56°.

- interramp slope angles in the Baby Zone metasediments will range from 53° to 56°, depending on wall orientation.

It is noteworthy that the incorporation of ramps into the pit slopes will result in a slope with a shallower overall slope angle than the interramp slope angles discussed above.

Because of the nature of open pits and geological conditions, final slopes often include small portions of wall which could theoretically be split off as separate small design sectors. Zones of transition between adjacent design sectors, or small portions within a larger design sector have not been considered in the above slope designs. In general, recommended slope angles should not be exceeded in these zones. However, because of the amount of berm width provided in the slope designs (i.e. to account for bench breakback), it is considered reasonable in such areas to allow slight deviations (i.e. within about 2°) in interramp slope angles from those recommended. While it is recognized that steepening could result in additional breakback and narrower berm widths, increasing the possibility of rockfalls, steepening or flattening the interramp slope in small areas would allow more rational incorporation and blending of the recommended slope designs into the overall pit plan.

While slope heights in excess of 24m are felt to be possible from a kinematic and slope stability standpoint, there may be some operational or other constraints that will preclude the use of higher benches. For example, if 36m high triple benches were utilized in some areas, it would probably be difficult to establish steep enough bench face angles (i.e. likely to be about 70°) and narrow enough berms (i.e. probably a minimum of 12m wide) such that the interramp slope angle could be significantly steepened. In addition, it will no doubt be more difficult and require more care with all phases of the excavation process to develop higher benches. Thus, to fully assess the slope designs, it is recommended that, as has been done in the past at East Kemptville, trial slopes be developed before final walls are excavated. These slopes should incorporate such practices as trial perimeter blasts to evaluate all aspects of potential wall steepening.

Trial slopes should be developed in areas where failures can be allowed to occur without affecting the efficiency and safety of the operation. If failures or other problems do occur on a particular trial section, provision should be made so that the failure can be controlled and the mining geometry can be modified without jeopardizing the safety of the mine.

Based on the results of trial slopes, ongoing geotechnical assessments and mine planning studies, updated slope designs can be prepared on an as-needed basis.

5.2 SLOPE GEOMETRY AND EXCAVATION TECHNIQUES

The hazard of local instability, rockfalls and general ravelling increases as both the jointing and blasting damage increases. Other than thorough scaling and possible local application of mesh and rockbolts, little can be done to control unfavorable effects of jointing. However, blasting damage can be minimized by control perimeter blasting on the final wall and careful production blasting. As it is recognized that considerable effort has already gone into developing and optimizing specific control perimeter blasting and production blasting techniques at the mine, the following are only intended as general comments.

5.2.1 Control Blasting

Control blasting is recommended in all areas of the interim and final pit walls to maintain rock mass strength within the slope and to control excessive bench breakback. Besides increasing the stability of the slope, certain types of control blasting on benches might allow larger charges to be used in production blasts. This could lead to increased efficiency and better flexibility to achieve the required fragmentation.

The type of control blasting to be used on the slopes depends on the results of blasting trials. Effects of using small diameter, closely spaced, inclined preshear holes, cushion blasting or post splitting, unstemmed and stemmed larger diameter holes with cardboard cartridges, buffer blasting, sequential blasting techniques in both cushion and buffer blasts as well as in the production blasts, etc. could be considered in blasting trials on interim slopes, as required.

To protect haulroads, it is sometimes necessary to use a more sophisticated or higher level of control blasting on the benches immediately above and below the haulroad. If control blasting is not sufficient to maintain the integrity of the slopes, berms may be reinforced by simple artificial support in site specific areas.

5.2.2 Production Blasting

Production blasting should be designed so that blasting damage to the pit wall is minimized. With regard to benches, for example, this can be achieved to some extent by reducing subgrade drilling and having blastholes span the proposed bench crest of the next bench below the one being blasted.

Accurate location of all blastholes by surveying is essential. Optimum results can only be obtained by varying blasting techniques and correctly supervising and designing field trials where loads, spacing, burden, delays, etc. are varied to obtain the best possible results. It is sound engineering to make special provision for a series of test blasts to ensure optimum results for existing operating conditions.

5.3 SURFACE WATER AND GROUNDWATER CONTROL

An efficient system of surface drainage ditches should be maintained to control surface water behind and in the pit, with surface water directed away from the pit. Ditches on haulroads and specific benches would also help to control runoff from both precipitation and snowmelt.

As discussed in Section 3.5, some drainage of the pit walls is expected as the pit is developed. Individual benches are expected to be well drained.

5.4 CLEANING BERMS AND SCALING

All benches should be adequately scaled to minimize rockfalls. This is particularly important if higher benches are utilized. If possible, berms should be kept relatively free of excessive buildup of rockfalls and ravelling material to maintain adequate catchments. While debris buildups may require cleanup at a later date in certain areas, experience with the pit to date indicates this should not be a significant problem. Ideally, if berms are accessible from both ends, access will not be lost if a bench failure occurs.

5.5 MONITORING SLOPES FOR MOVEMENT

Performance of all slopes should be carefully evaluated on an ongoing basis by regular visual field surveys and the use of prism monitoring to detect slope displacements. Movement of the top, as well as the bottom, of slopes should be recorded. It is recommended that a series of monitoring prisms be installed at a few key locations on the slopes.

Because of the difficulty of making absolute predictions about the behaviour of the slope, there is always the possibility that the most carefully engineered slope will become unstable and will require remedial measures. Thus, the purpose of monitoring would be to provide data about the current and anticipated stability of the slope. Also, this data would assist in making rational design modifications as mining proceeds.

5.6 SUMMARY OF RECOMMENDATIONS FOR FURTHER GEOTECHNICAL WORK

A number of additional tasks which should be carried out by mine personnel to further evaluate and update the slope design studies outlined herein are summarized in the following. Piteau Associates would be pleased to assist RKTC with planning and initiating this work.

i) Geologic Structural Mapping

Because of the importance of geological structure to slope design, detailed geologic structural mapping should be carried out on an ongoing basis by mine personnel as mining proceeds. Mapping of any major faults and/or fault sets and joint sets should be carried out to update the geological structural mapping, to determine if the structural populations are changing, and thus, to determine if any slope design modifications are required.

ii) Core Logging

To assist in keeping the geotechnical data base up to date and to confirm the extent and continuity of what appears to be a competent rock mass, it is recommended that diamond drill core from any future exploration programs be carefully logged. Core from the diamond drillholes should be drilled and handled with care and geotechnically logged immediately after being drilled and before being split.

iii) Documentation and Back Analysis of Failures

Documentation and back analyses of any slope failures which might occur should be carried out to obtain additional information on the strength of the discontinuities or rock mass. A periodic visual inspection of the pit should be carried out to detect visible signs of movement.

6. ACKNOWLEDGEMENTS

The author acknowledges with thanks the assistance and cooperation of mine personnel during the course of this work. Particular thanks are expressed to Messrs. J. Davis, C. McAleenan and J. Smith.

Respectfully submitted,

PITEAU ASSOCIATES ENGINEERING LTD.

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Alan F. Stewart, P.Eng.

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FIGURES

(Piteau Associates' Report)

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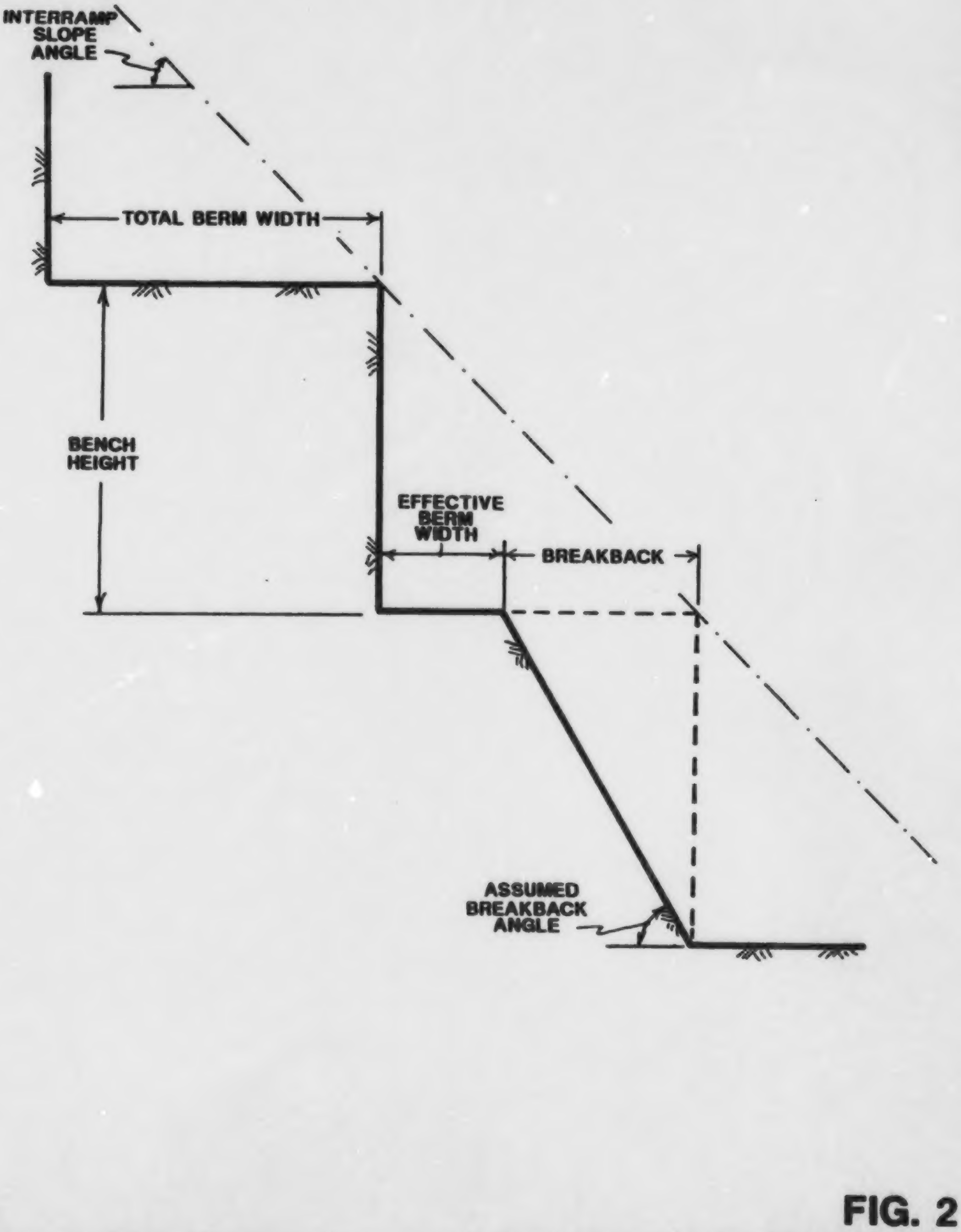
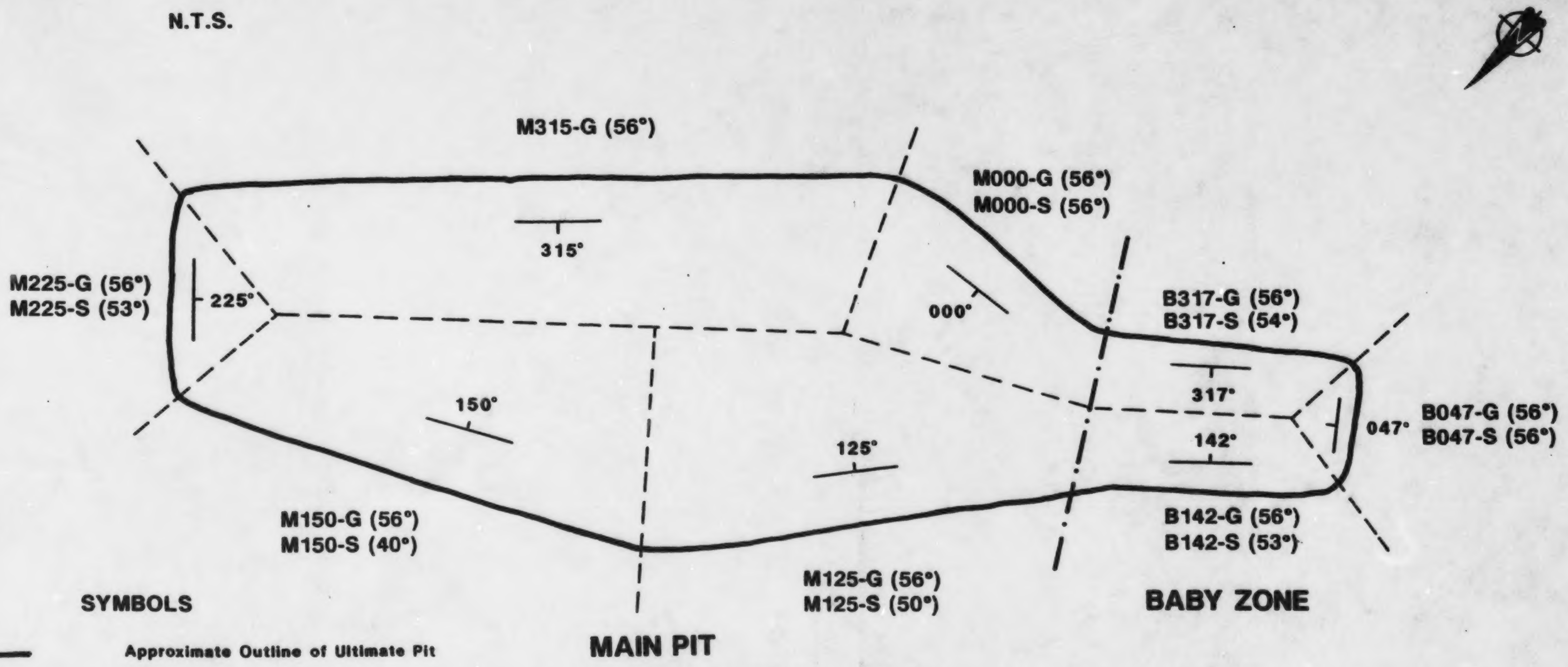


FIG. 2

RIO KEMPTVILLE TIN CORPORATION EAST KEMPTVILLE MINE SLOPE STABILITY ASSESSMENT	PITEAU ASSOCIATES GEOTECHNICAL CONSULTANTS VANCOUVER CALGARY

SLOPE GEOMETRY PARAMETERS	BY: JDT	DATE: DEC.91
	APPROVED:	DWG:

JOB NUMBER 89-159



N.T.S.

SYMBOLS

━━━	Approximate Outline of Ultimate Pit
– – –	Design Sector Boundary
150° ⊥	Slope Orientati n showing Slope Dip Dire tion
M150-G (56°)	Design Sector showing Interramp Slope Angle for the Rock Type Indicated (S = Metasediments; G = Granites)

NOTES:

1. Plan is schematic only. Orientations assumed for final walls based on orientations of the existing pit walls.
2. Interramp slope angles assume 24m high double benches.

FIG. 3

RIO KEMPTVILLE TIN CORPORATION
EAST KEMPTVILLE MINE
SLOPE STABILITY ASSESSMENT

PITEAU ASSOCIATES
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

SLOPE DESIGN SECTORS AND PROPOSED INTERRAMP SLOPE ANGLES

BY: JDT
DATE: JAN.92

TABLES

(Piteau Associates' Report)

TABLE I
PEAK ORIENTATIONS OF DISCONTINUITY SETS [1,2]

MINE AREA	ROCK TYPE	INFORMATION SOURCE	POP.	SET 1				SET2				SET 3				SET 4				SET 5			
				SET	DIP DIR.	DIP	%/No.[3]	SET	DIP DIR.	DIP	%/No.	SET	DIP DIR.	DIP	%/No.	SET	DIP DIR.	DIP	%/No.	SET	DIP DIR.	DIP	%/No.
MAIN PIT	GRANITES	SURFACE MAPPING	523	S1A	183	82	8/42	S2A	205	81	4/21	S3A	082	79	5/26	S4A	300	88	7/33	S5A	307	18	1/5
				SIB	158	78	8/42	S2B	044	82	3/16					S4B	120	85	6/31				
		UNDERGROUND MAPPING	571	U1A	155	86	3/17	U2A	194	85	8/46	-	-	-	-	U4A	303	85	3/17	U5A	310	09	6/34
																U4B	121	85	3/17				
	META-SEDIMENTS	SURFACE MAPPING	344	D1A	170	82	3/10	D2A	222	88	12/41	D3A	282	79	6/21	D4A	300	90	8/28	-	-	-	-
								D2B	200	88	7/24	D3B	100	72	3/10	D4B	317	87	5/17				
																D4C	140	52	2/7				
BABY ZONE	GRANITES	SURFACE MAPPING	51	DS1	172	80	17/9	D2A	200	77	10/5	DS3	089	88	19/10	D4A	121	85	17/9	-	-	-	-
								D2B	044	89	12/6					D4B	109	84	10/5				
	META-SEDIMENTS		163	DS1	180	87	13/21	D2A	202	79	8/13	-	-	-	-	D4A	114	79	11/18	DS5	299	08	2/3
								D2B	055	78	5/8					D4B	129	79	9/15				
								D2C	227	79	4/7					D4C	311	73	10/16				
																D4D	315	47	4/7				

NOTES:
1. Based on surface and underground mapping data provided by Rio Kemptville personnel.
2. Orientations are given as true dip direction and dip for the peak or average orientation of each joint set.
3. "%/No." refers to the percent concentration and corresponding number of joints in a one percent area of the lower hemisphere equal area projection for the average or peak orientation of the population.
4. Where only surface mapping data available, prefix "D" used for data set labels. Where information available from both surface and underground mapping, prefix "S" used for surface data, and "U" used for underground data.

TABLE II

SUMMARY OF DESIGN SECTORS, WEDGE AND PLANE FAILURE KINEMATICS AND ASSOCIATED SLOPE DESIGN

DESIGN SECTOR[6]	MINE AREA	SLOPE DIP DIR'N (°)	ROCK TYPE	PRINCIPAL KINEMATIC CONTROLS (PRINCIPAL FAILURE MODES CONSIDERED TO CONTROL BENCH STABILITY)				BENCH FACE ANGLE ASSUMED FOR DESIGN FOR BENCH HEIGHTS GIVEN[2]		POSSIBLE SLOPE GEOMETRIES BASED ON KINEMATIC ANALYSES OF WEDGE AND PLANE FAILURES[3]						COMMENTS
				TYPE OF FAILURE	DISCONTINUITY SET(S) INVOLVED	INTENSITY/[1] IMPORTANCE	APPARENT PLUNGE OR DIP CONTROLLING SLOPE DESIGN (°)			ANTICIPATED BREAKBACK AT BENCH CRESTS ASSUMING 90° DESIGN BENCH FACE ANGLES		TOTAL BERM WIDTHS FOR VARIOUS BENCH HEIGHTS[5] (m)		INTERRAMP SLOPE ANGLES FOR VARIOUS BENCH HEIGHTS (°)		
								12m	24m	12m	24m	12m	24m	12m	24m	
M125-S	MAIN PIT	125	Sediments	Wedge	2/3	Strong/Moderate	67	67	67	5.0	10.1	13.0	20.1	43	50	Bench Face Angle compares favourably with Bench Face Angles observed in field.
M125-G			Granites	Wedge	1/2	Strong/Strong	75	75	75	3.2	6.4	11.2	16.4	47	56	
M150-S		150	Sediments	Plane	4	Moderate	52	52	52	9.4	18.8	17.4	28.8	35	40	Shallow dipping subset of Joint Set 4 moderately developed in this area. Existence confirmed by field observations.
M150-G			Granites	Plane Wedge	1 1/2	Strong Strong/Strong	75	75	75	3.2	6.4	11.2	16.4	47	56	
M225-S		225	Sediments	Wedge	1/4	Moderate/Strong	71	71	71	4.1	8.3	12.1	18.3	45	53	
M225-G			Granites	Wedge	1/4	Strong/Strong	77	77	75	2.8	6.4	10.8	16.4	48	56	
M315-G		315	Granites	Wedge	3/4	Moderate/Strong	80	80	75	2.1	6.4	10.1	16.4	50	56	
M000-S		000	Sediments	Wedge	2/3	Strong/Moderate	84	80	75	2.1	6.4	10.1	16.4	50	56	
M000-G			Granites	Wedge	2/4	Strong/Strong	79	79	75	2.3	6.4	10.3	16.4	49	56	
B317-S	BABY ZONE	317	Sediments	Plane	4	Strong	73	73	73	3.7	7.3	11.7	17.3	46	54	Flatter plane dipping at 47° is weakly developed.
B317-G			Granites	–[4]	–	–	–	80	75	2.1	6.4	10.1	16.4	50	56	May be susceptible to toppling.
B047-S		047	Sediments	Plane	2	Strong	78	78	75	2.6	6.4	10.6	16.4	49	56	
B047-G			Granites	Wedge	1/2	Strong/Strong	88	80	75	2.1	6.4	10.1	16.4	50	56	
B142-S		142	Sediments	Wedge	2/4	Strong/Strong	72	72	72	3.9	7.8	11.9	17.8	45	53	
B142-G			Granites	Wedge	1/2	Strong/Strong	76	76	75	3.0	6.4	11.0	16.4	47	56	

NOTES:

1. Intensity/importance refers to the relative degree of development of individual joint sets in a given failure mode and the estimated likelihood of excavated bench faces breaking back to or forming along this failure mode.
2. For design, bench face angles are assumed to be a maximum of 80° for 12m single benches, and 75° for 24m double benches. Where the apparent plunges or dips of failure are less than these values, the lower value has been used for the bench face angle.
3. See Fig. 3 for definition of slope geometry parameters.
4. "–" indicates no strong kinematic control is present.
5. For 12m and 24m high benches, effective berm widths for access, rockfall catchment, etc. are assumed to be 8m and 10m, respectively.
6. Design Sectors are named for their location (i.e. M for Main Pit; B for Baby Zone), slope orientation (eg. 000°), and rock type (eg. G for Granites, S for Metasediments).

APPENDICES

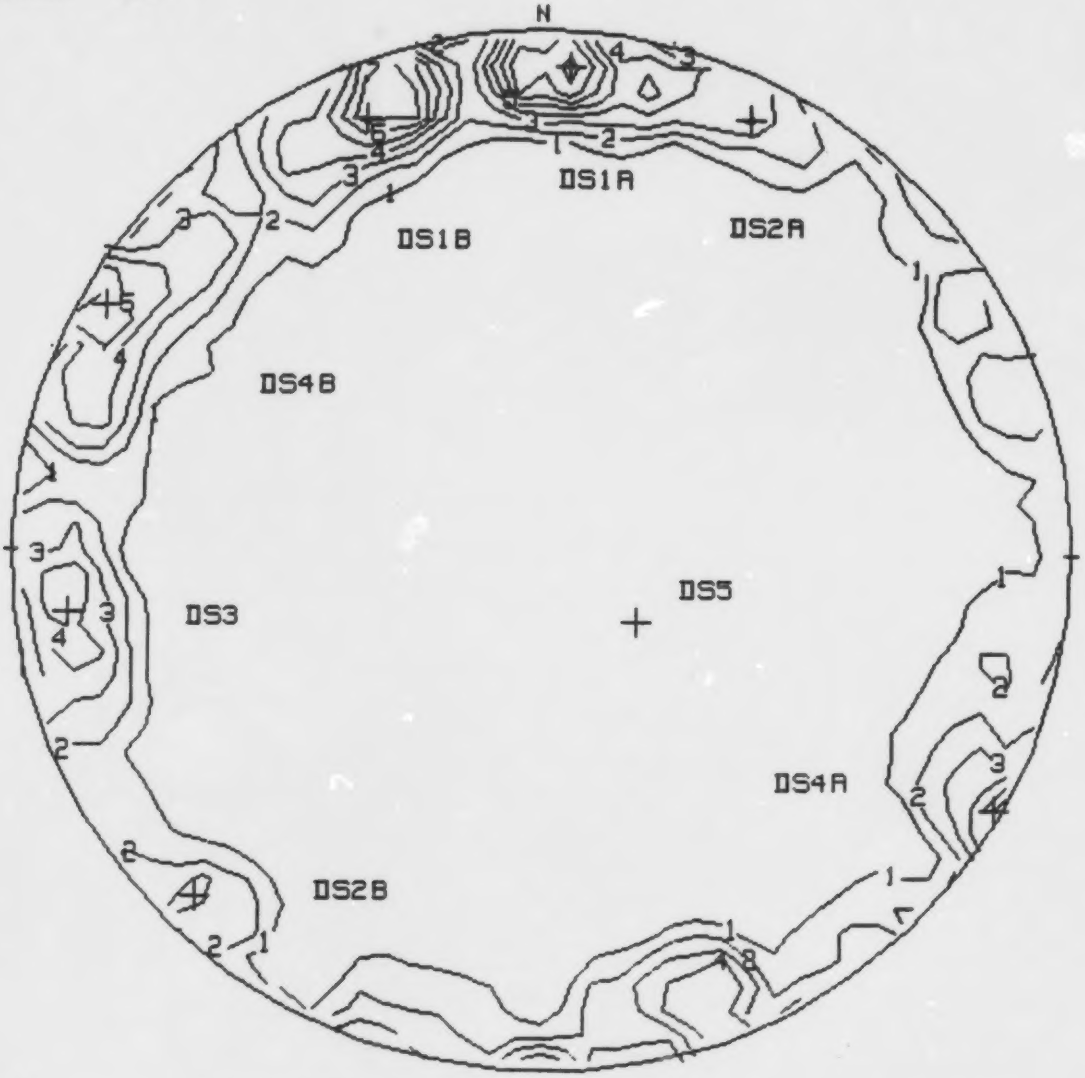
(Piteau Associates' Report)

APPENDIX A

LOWER HEMISPHERE EQUAL AREA PROJECTIONS
OF DISCONTINUITY POPULATIONS

OBSERVATIONS: 232
POPULATION: 523

CONTOUR PLOT



LABEL	DIP DIRECTION	DIP	CONCENTRATION (%)
DS1A	183	82	8
DS1B	158	78	8
DS2A	205	81	4
DS2B	044	82	3
DS3	082	79	5
DS4A	300	88	7
DS4B	120	85	6
DS5	307	18	1

RIO KEMPTVILLE TIN CORPORATION
EAST KEMPTVILLE MINE
SLOPE STABILITY ASSESSMENT

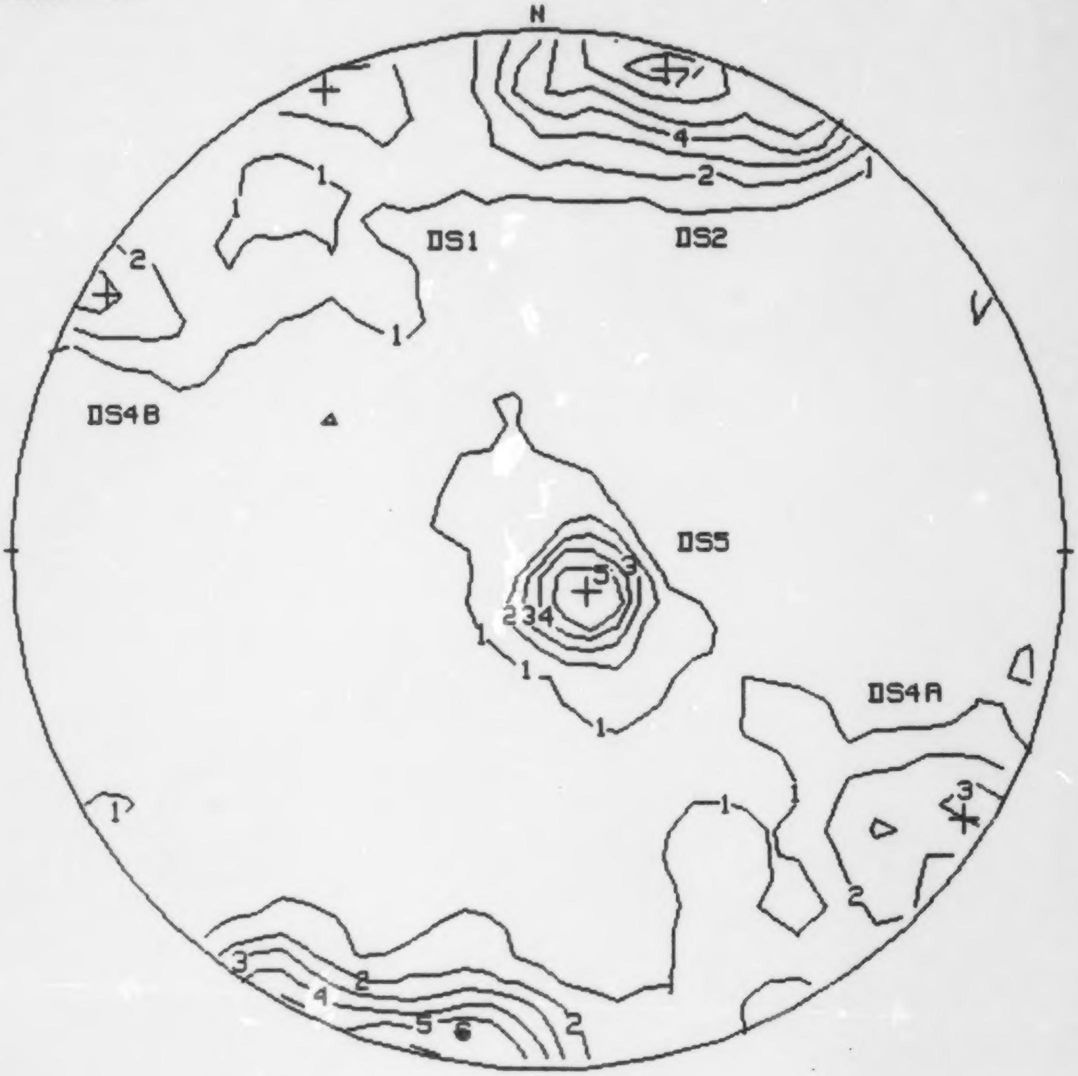
PITEAU ASSOCIATES
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

GEODAT: LOWER HEMISPHERE EQUAL AREA PROJECTION
ALL SURFACE DATA IN GRANITES (MAIN PIT)

By: JDT
Date: DEC.91
Page: A-1
Job#:

OBSERVATIONS: 571
POPULATION: 571

CONTOUR PLOT



LABEL	DIP DIRECTION	DIP	CONCENTRATION (%)
DS1	155	86	3
DS2	194	85	8
DS4A	303	85	3
DS4B	121	85	3
DS5	310	09	6

RIO KEMPTVILLE TIN CORPORATION
EAST KEMPTVILLE MINE
SLOPE STABILITY ASSESSMENT

PITEAU ASSOCIATES
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

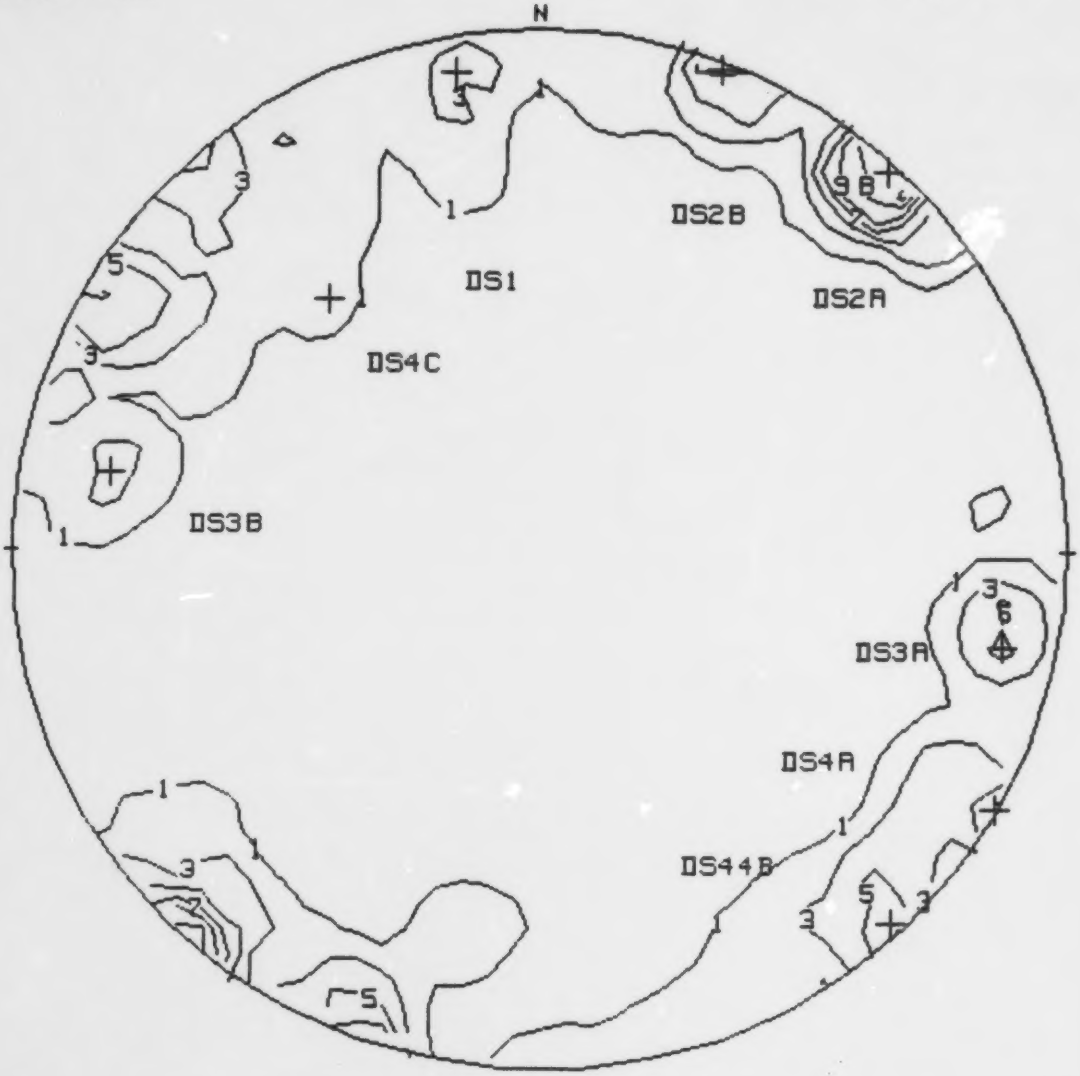
GEODAT: LOWER HEMISPHERE EQUAL AREA PROJECTION

ALL U/G STRUCTURAL DATA (GRANITES)

By: JDT	**Date:** DEC.91
Page: A-2	**Job#:**

OBSERVATIONS: 128
POPULATION: 344

CONTOUR PLOT



LABEL	DIP DIRECTION	DIP	CONCENTRATION (%)
DS1	170	82	3
DS2A	222	88	12
DS2B	200	88	7
DS3A	282	79	6
DS3B	100	72	3
DS4A	300	90	8
DS44B	317	87	5
DS4C	140	52	2

RIO KEMPTVILLE TIN CORPORATION
EAST KEMPTVILLE MINE
SLOPE STABILITY ASSESSMENT

PITEAU ASSOCIATES
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

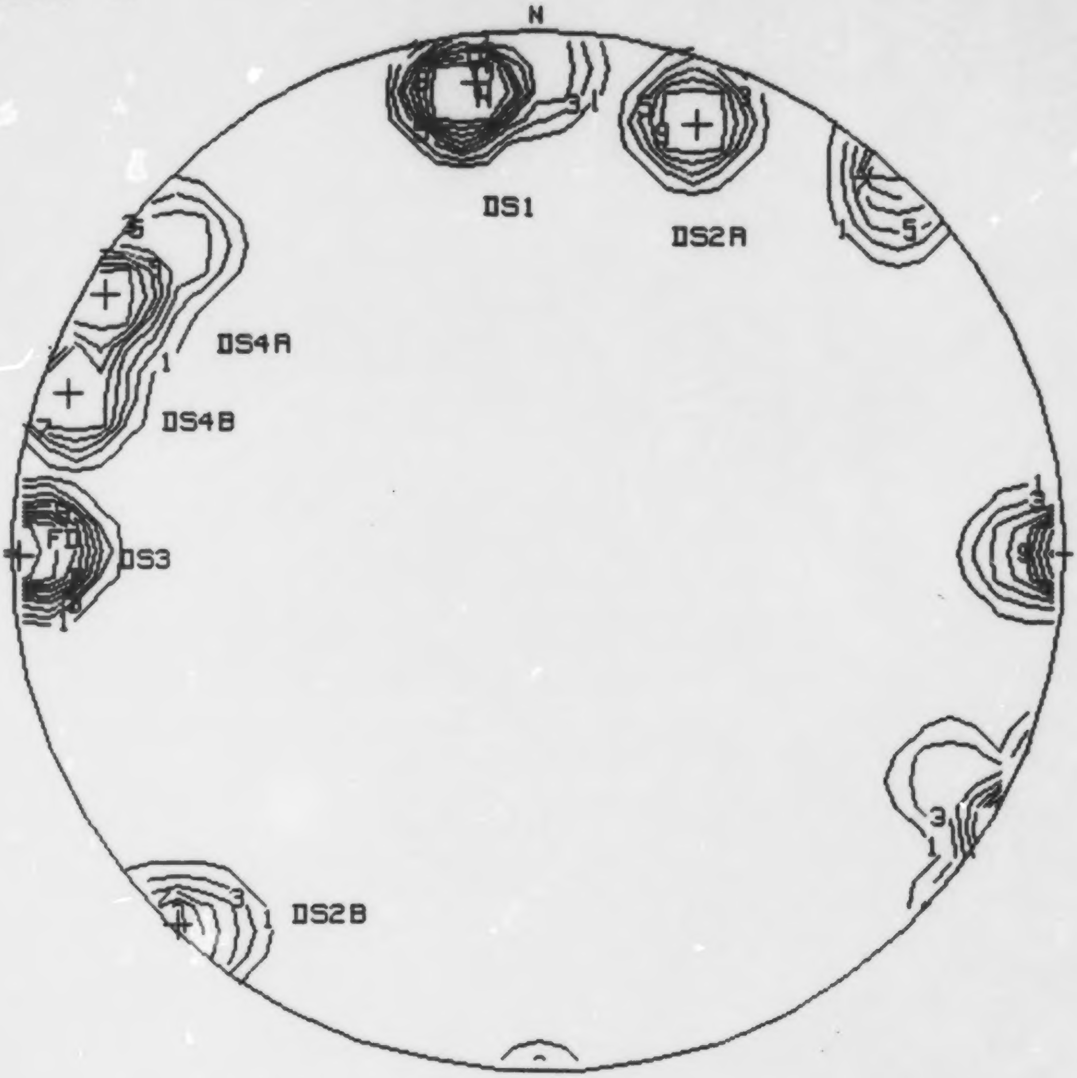
GEODAT: LOWER HEMISPHERE EQUAL AREA PROJECTION

ALL DATA IN SEDIMENTS - MAIN PIT

By: **JDT**
Date: **DEC.91**
Page: **A-3**
Job#:

OBSERVATIONS: 15
POPULATION: 51

CONTOUR PLOT



LABEL	DIP DIRECTION	DIP	CONCENTRATION (%)
DS1	172	80	17
DS2A	200	77	10
DS2B	044	89	12
DS3	089	88	19
DS4A	121	85	17
DS4B	109	84	10

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EAST KEMPTVILLE MINE
SLOPE STABILITY ASSESSMENT

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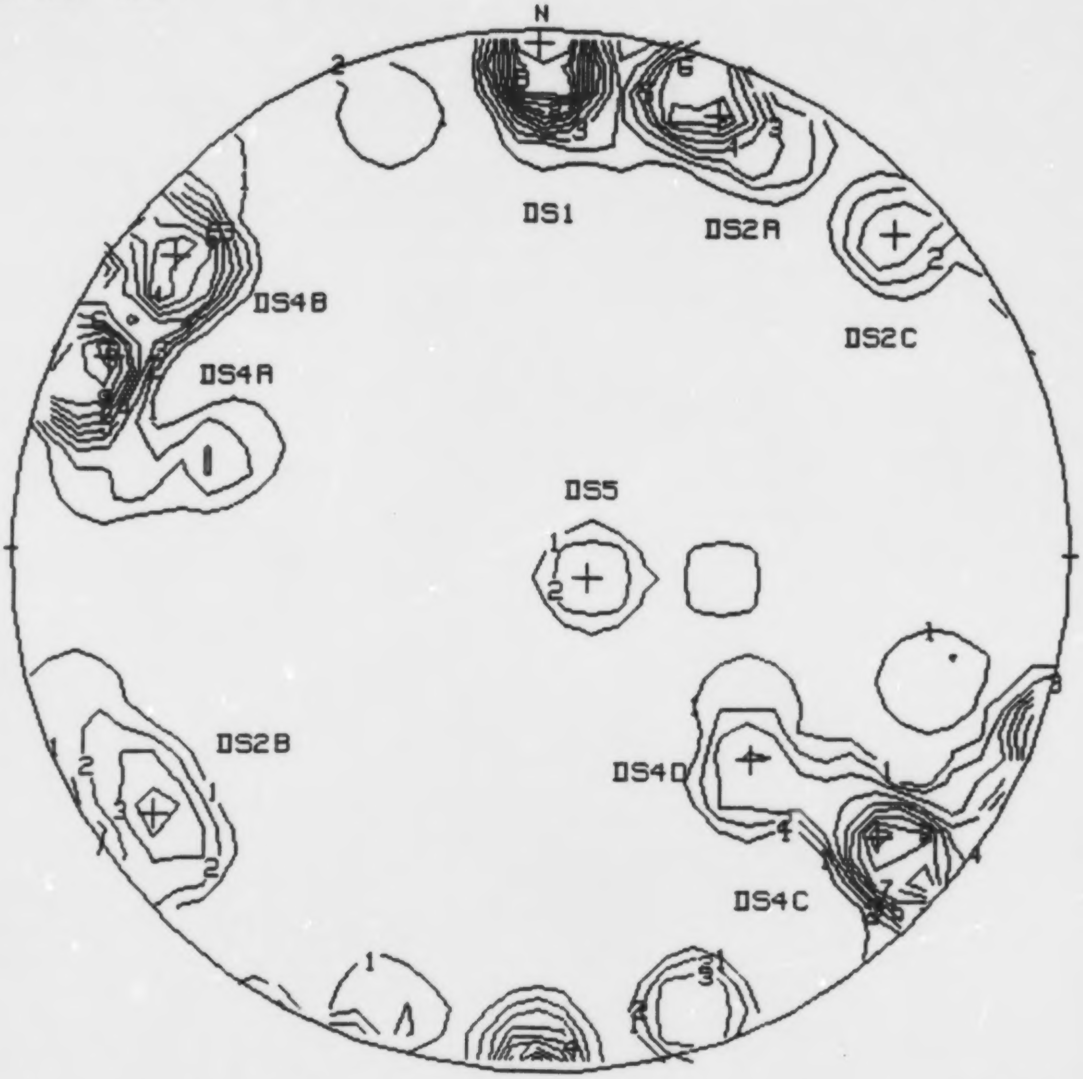
VANCOUVER CALGARY

GEODAT: LOWER HEMISPHERE EQUAL AREA PROJECTION
ALL DATA IN GRANITES - BABY ZONE

By: JDT
Date: DEC.91
Page: A-4
Job#:

OBSERVATIONS: 56
POPULATION: 163

CONTOUR PLOT



LABEL	DIP DIRECTION	DIP	CONCENTRATION (%)
DS1	180	87	13
DS2A	202	79	8
DS2B	055	78	5
DS2C	227	79	4
DS4A	114	79	11
DS4B	129	79	9
DS4C	311	73	10
DS4D	315	47	4
DS5	299	08	2

RIO KEMPTVILLE TIN CORPORATION
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SLOPE STABILITY ASSESSMENT

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GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

GEODAT: LOWER HEMISPHERE EQUAL AREA PROJECTION

ALL DATA IN SEDIMENTS - BABY ZONE

By: **JDT**
Date: **DEC.91**
Page: **A-5**
Job#:

APPENDIX B

RELATIONSHIP BETWEEN HARDNESS AND UNCONFINED COMPRESSIVE STRENGTH

QUALITATIVE & QUANTITATIVE EXPRESSIONS
FOR CONSISTENCY OF COHESIVE SOIL AND ROCK*

HARDNESS	CONSISTENCY	FIELD IDENTIFICATION	APPROXIMATE RANGE OF UNCONFINED COMPRESSIVE STRENGTH	
			MPa	p.s.i.
S1	very soft soil	Easily penetrated several inches by fist; shows distinct heel marks.	<0.025	<3.5
S2	soft soil	Easily penetrated several inches by thumb; faint heel marks.	0.025 - 0.05	3.5 - 7
S3	firm soil	Can be penetrated by thumb with moderate effort; difficult to cut with hand spade.	0.05 - 0.10	7 - 14
S4	stiff soil	Readily indented by thumb but penetrated only with great effort; cannot be cut with hand spade.	0.1 - 0.2	14 - 28
S5	very stiff soil	Readily indented by thumbnail; requires pneumatic spade for excavation.	0.20 - 0.4	28 - 56
S6	hard soil	Indented with difficulty by thumbnail.	>0.4	>56
R0	extremely soft rock	Indented by thumbnail.	0.2 - 0.7	28 - 100
R1	very soft rock	Crumbles under firm blows with point of geological pick; can be peeled by a pocket knife.	0.7 - 7.0	100 - 1,000
R2	soft rock	Can be peeled by a pocket knife with difficulty; shallow indentations made by firm blow of geological pick.	7.0 - 28	1,000 - 4,000
R3	average rock	Cannot be scraped or peeled with a pocket knife; specimen can be fractured with single firm blow of hammer end of geological pick.	28 - 56	4,000 - 8,000
R4	hard rock	Specimen requires more than one blow with hammer end of geological pick to fracture it.	56 - 112	8,000 - 16,000
R5	very hard rock	Specimen requires many blows of hammer end of geological pick to fracture it.	112 - 224	16,000 - 32,000
R6	extremely hard rock	Specimen can only be chipped with geological pick.	>224	>32,000

* Modified Rock Hardness Classification

S1 to S6 Modified after Terzaghi, K. and Peck, R.B., 1967. "Soil Mechanics in Engineering Practice, 2nd Edition, John Wiley and Sons Inc., New York. p.30.

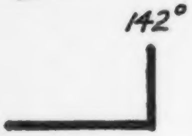
R1 to R5 Modified after Piteau, D.R., 1970. "Geological Factors Significant to the Stability of Slopes Cut in Rock" in Planning Open Pit Mines, Van Rensburg Ed. Aug. 29-Sept. 4, 1970. Balkema. p.51 and 68.

APPENDIX C

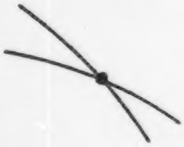
LOWER HEMISPHERE EQUAL AREA PROJECTIONS OF KINEMATICALLY POSSIBLE FAILURE MODES IN DESIGN SECTORS

JOB NUMBER

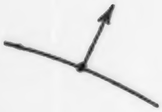
Plane representing Subset A of Discontinuity Set 4



Orientation of Design Sector



Kinematically possible Wedge Failures



Kinematically possible Plane Failures

RIO KEMPTVILLE TIN CORPORATION
EAST KEMPTVILLE MINE
SLOPE STABILITY ASSESSMENT

PITEAU ASSOCIATES
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

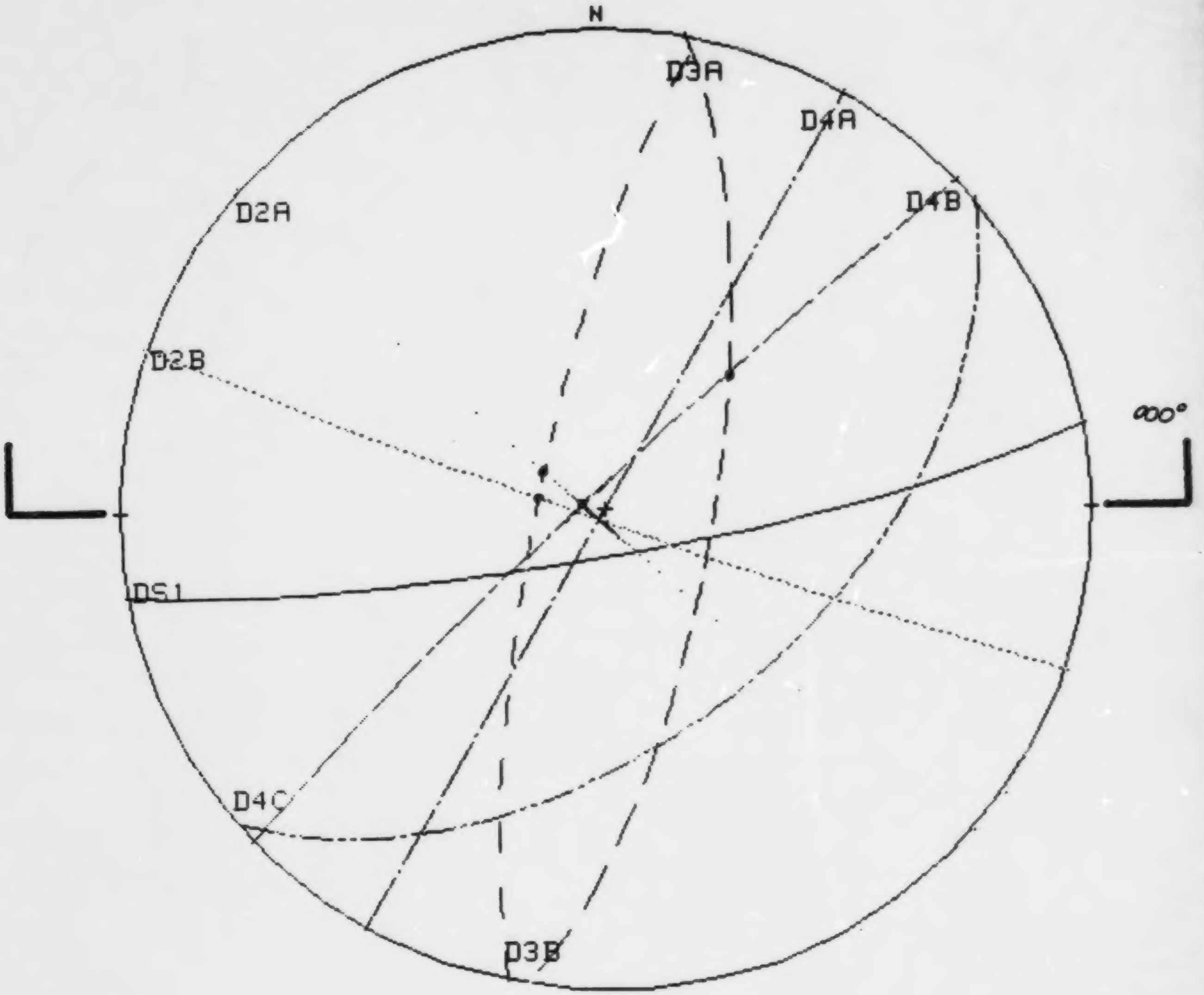
BY: JDT
DATE: DEC.91
APPROVED:
DWG:

KEY TO KINEMATIC PROJECTIONS

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

M000-S

STRUCTURAL DOMAIN: SEDIMENTS - MAIN

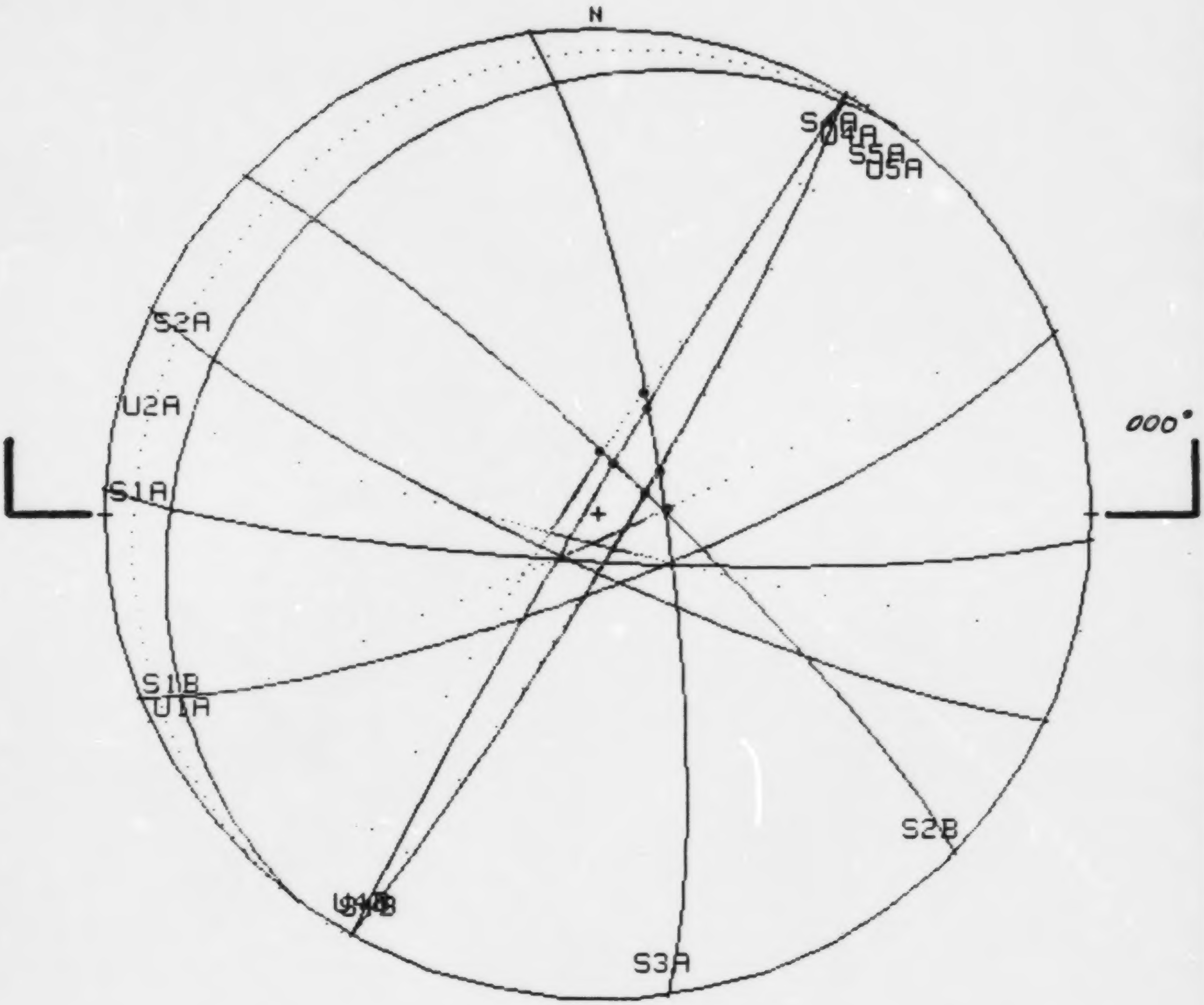


PLANE	AZI	DIP	NUMBER	C	PHI
DS1	170	82	10.0	0.0	30
D2A	222	88	41.0	0.0	30
D2B	200	88	24.0	0.0	30
D3A	282	79	21.0	0.0	30
D3B	100	72	10.0	0.0	30
D4A	300	90	28.0	0.0	30
D4B	317	87	17.0	0.0	30
D4C	140	52	7.0	0.0	30

M000-G

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

STRUCTURAL DOMAIN: GRANITES - MAIN

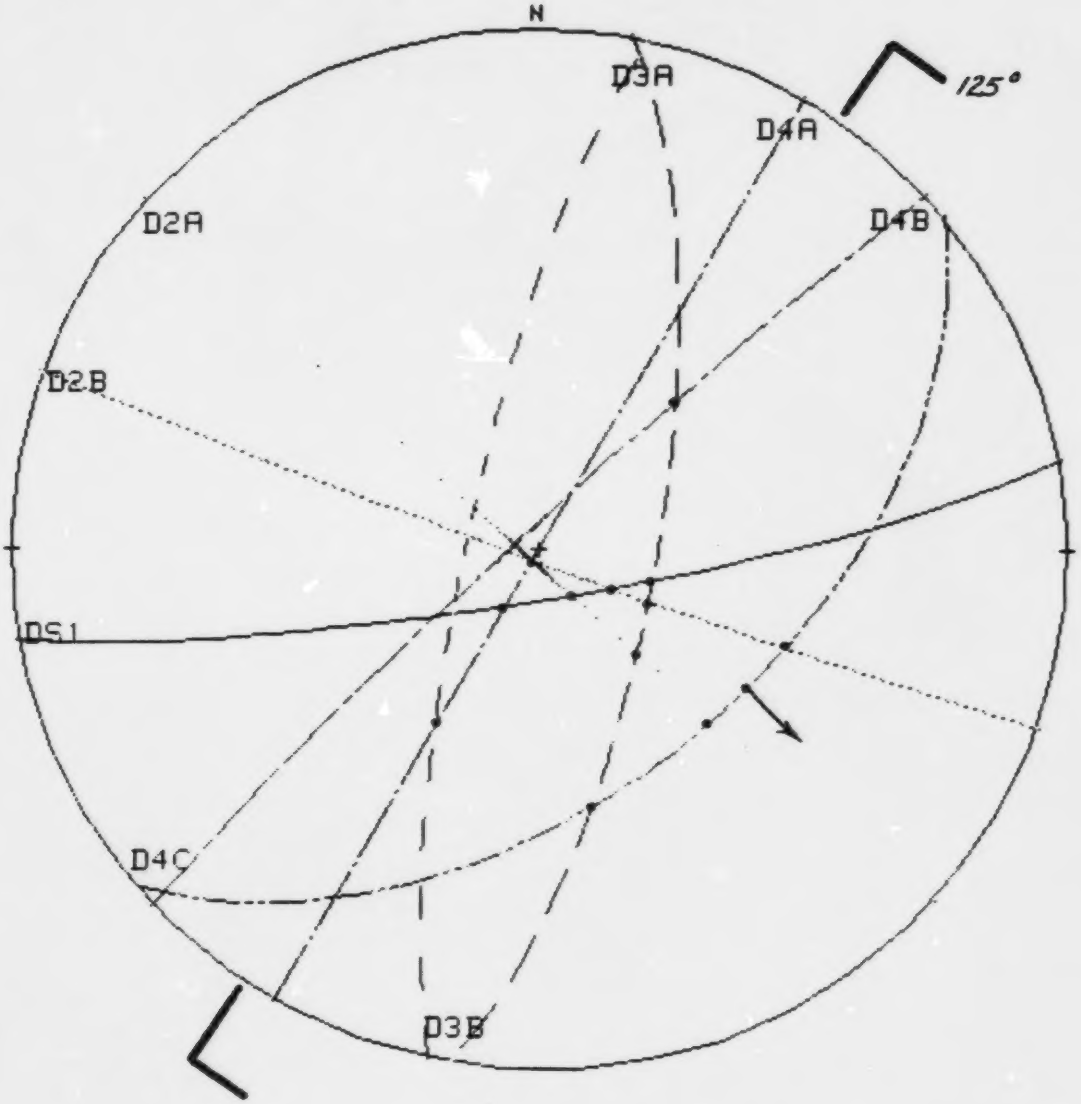


PLANE	AZI	DIP	NUMBER	C	PHI
S1A	183	82	42.0	0.0	30
S1B	158	78	42.0	0.0	30
S2A	205	81	21.0	0.0	30
S2B	044	82	16.0	0.0	30
S3A	082	79	26.0	0.0	30
S4A	300	88	33.0	0.0	30
S4B	120	85	31.0	0.0	30
S5A	307	18	5.0	0.0	30
U1A	155	86	17.0	0.0	30
U2A	194	85	46.0	0.0	30
U4A	303	85	17.0	0.0	30
U4B	121	85	17.0	0.0	30
U5A	310	09	5.0	0.0	30

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

M125-S

STRUCTURAL DOMAIN: SEDIMENTS - MAIN

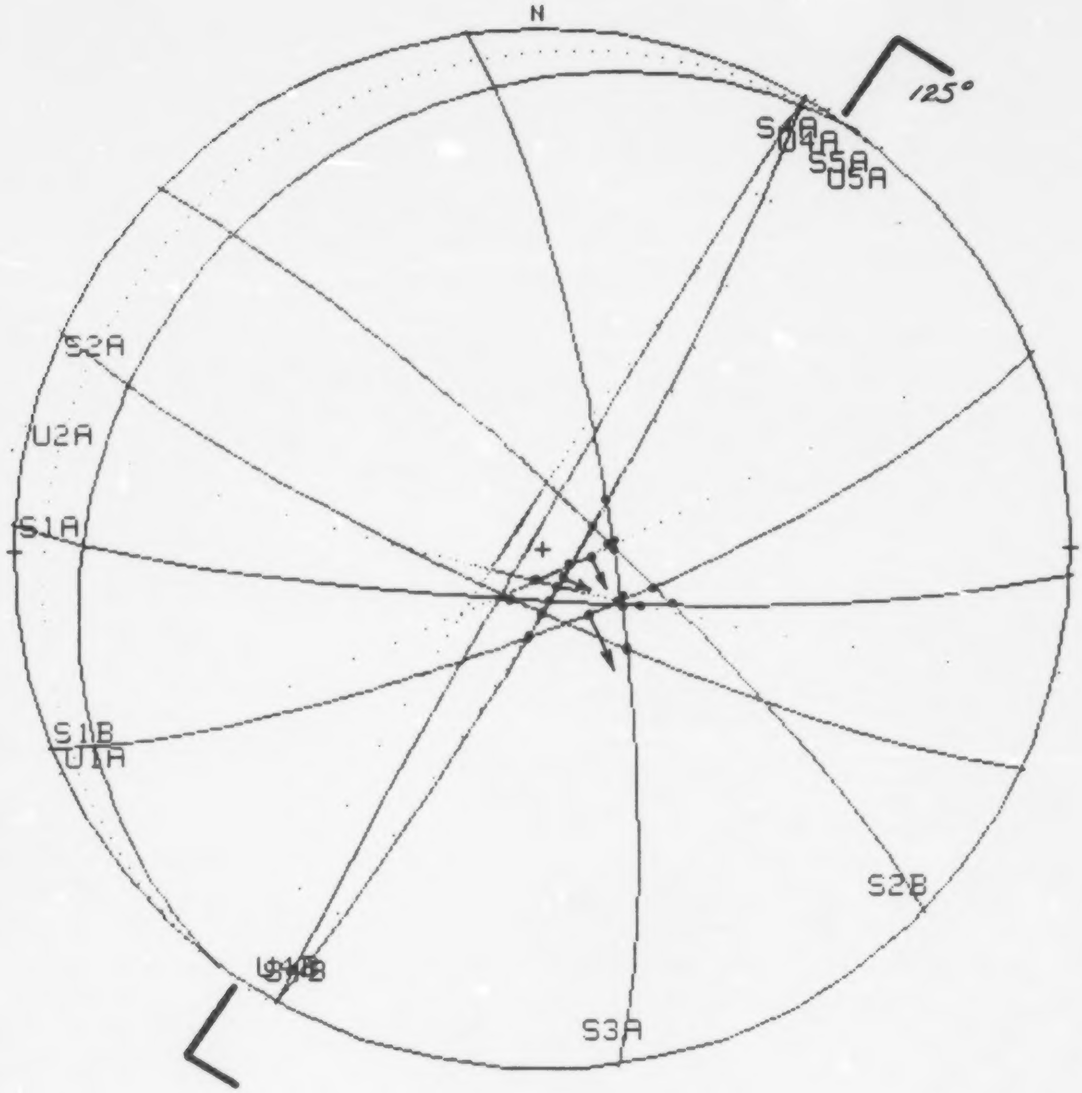


PLANE	AZI	DIP	NUMBER	C	PHI
DS1	170	82	10.0	0.0	30
D2A	222	88	41.0	0.0	30
D2B	200	88	24.0	0.0	30
D3A	282	79	21.0	0.0	30
D3B	100	72	10.0	0.0	30
D4A	300	90	28.0	0.0	30
D4B	317	87	17.0	0.0	30
D4C	140	52	7.0	0.0	30

M125-G

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

STRUCTURAL DOMAIN: GRANITES - MAIN

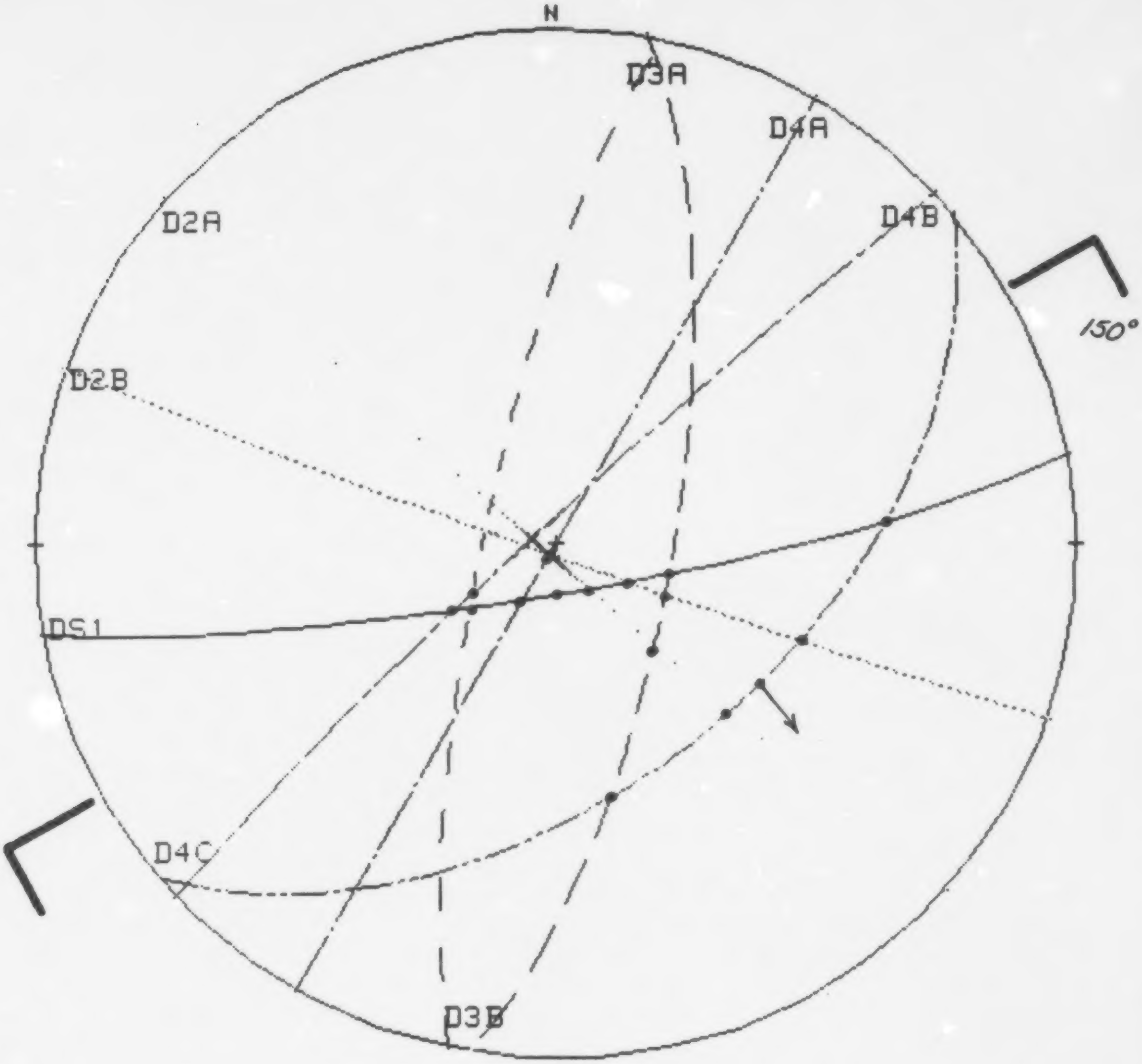


PLANE	AZI	DIP	NUMBER	C	PHI
S1A	183	82	42.0	0.0	30
S1B	158	78	42.0	0.0	30
S2A	205	81	21.0	0.0	30
S2B	044	82	16.0	0.0	30
S3A	082	79	26.0	0.0	30
S4A	300	88	33.0	0.0	30
S4B	120	85	31.0	0.0	30
S5A	307	18	5.0	0.0	30
U1A	155	86	17.0	0.0	30
U2A	194	85	46.0	0.0	30
U4A	303	85	17.0	0.0	30
U4B	121	85	17.0	0.0	30
U5A	310	09	5.0	0.0	30

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

M150-S

STRUCTURAL DOMAIN: SEDIMENTS - MAIN

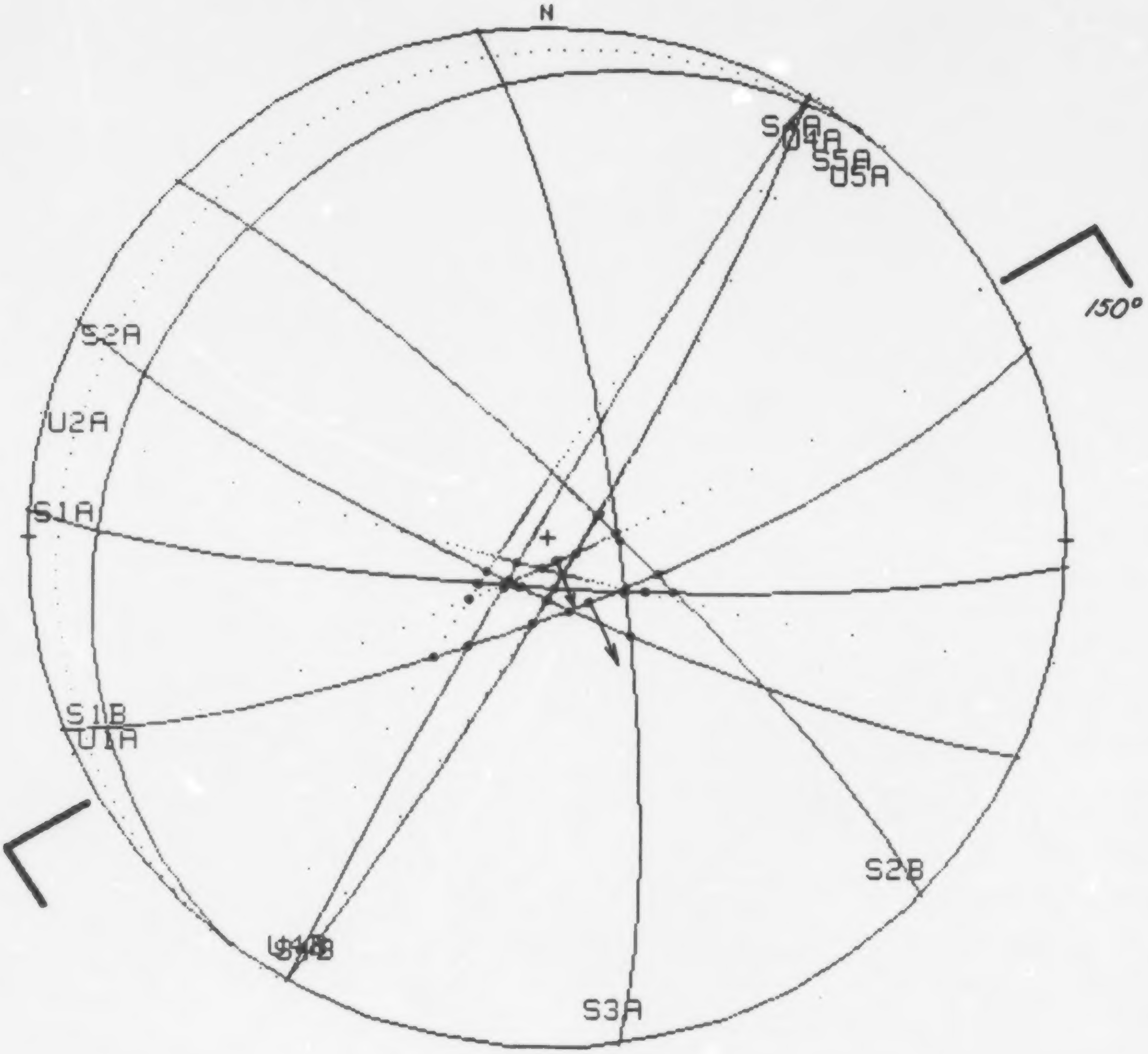


PLANE	AZI	DIP	NUMBER	C	PHI
DS1	170	82	10.0	0.0	30
D2A	222	88	41.0	0.0	30
D2B	200	88	24.0	0.0	30
D3A	282	79	21.0	0.0	30
D3B	100	72	10.0	0.0	30
D4A	300	90	28.0	0.0	30
D4B	317	87	17.0	0.0	30
D4C	140	52	7.0	0.0	30

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

M150-G

STRUCTURAL DOMAIN: GRANITES - MAIN

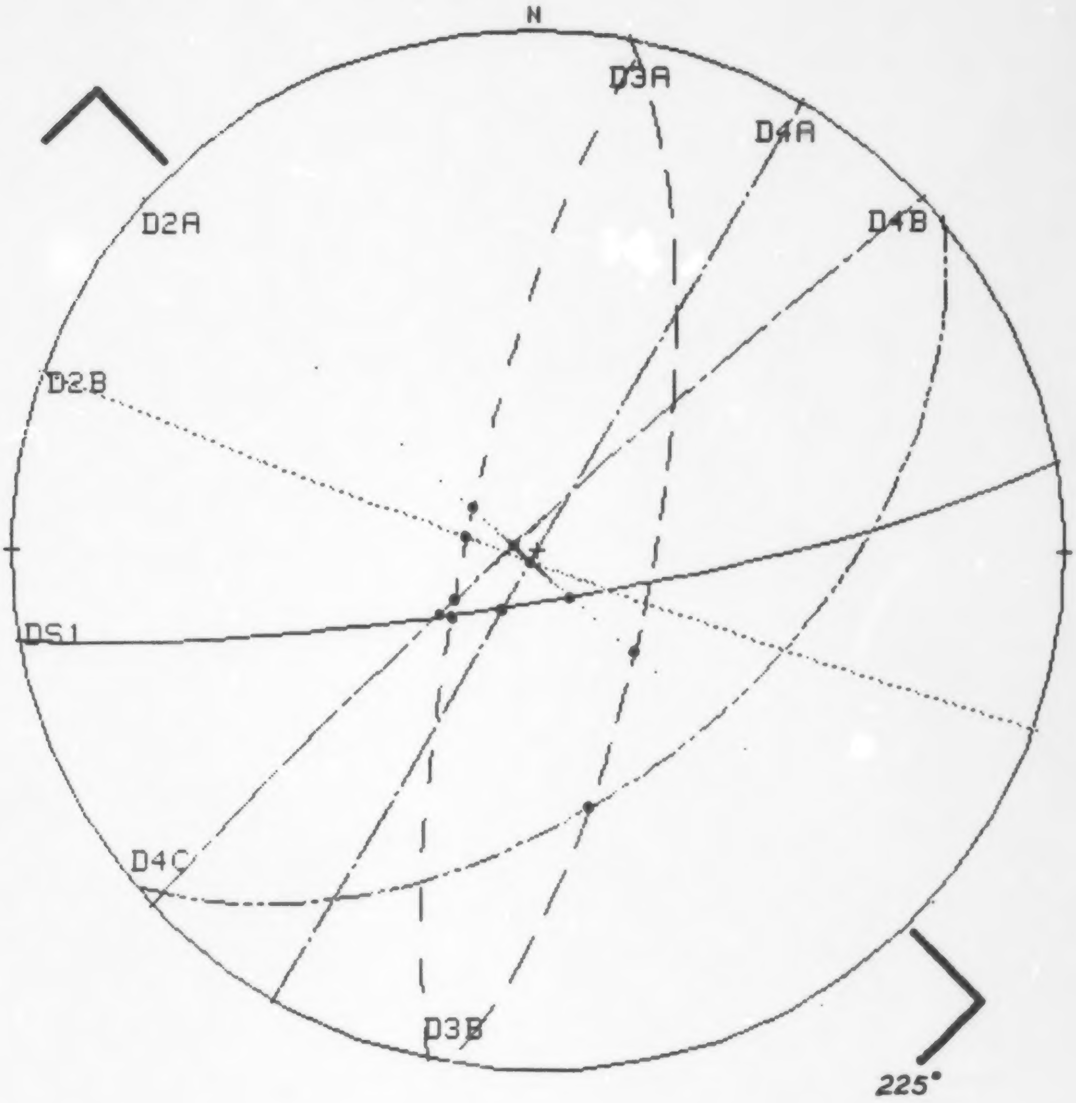


PLANE	AZI	DIP	NUMBER	C	PHI
S1A	183	82	42.0	0.0	30
S1B	158	78	42.0	0.0	30
S2A	205	81	21.0	0.0	30
S2B	044	82	16.0	0.0	30
S3A	082	79	26.0	0.0	30
S4A	300	88	33.0	0.0	30
S4B	120	85	31.0	0.0	30
S5A	307	18	5.0	0.0	30
U1A	155	86	17.0	0.0	30
U2A	194	85	46.0	0.0	30
U4A	303	85	17.0	0.0	30
U4B	121	85	17.0	0.0	30
U5A	310	09	5.0	0.0	30

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

M225-S

STRUCTURAL DOMAIN: SEDIMENTS - MAIN

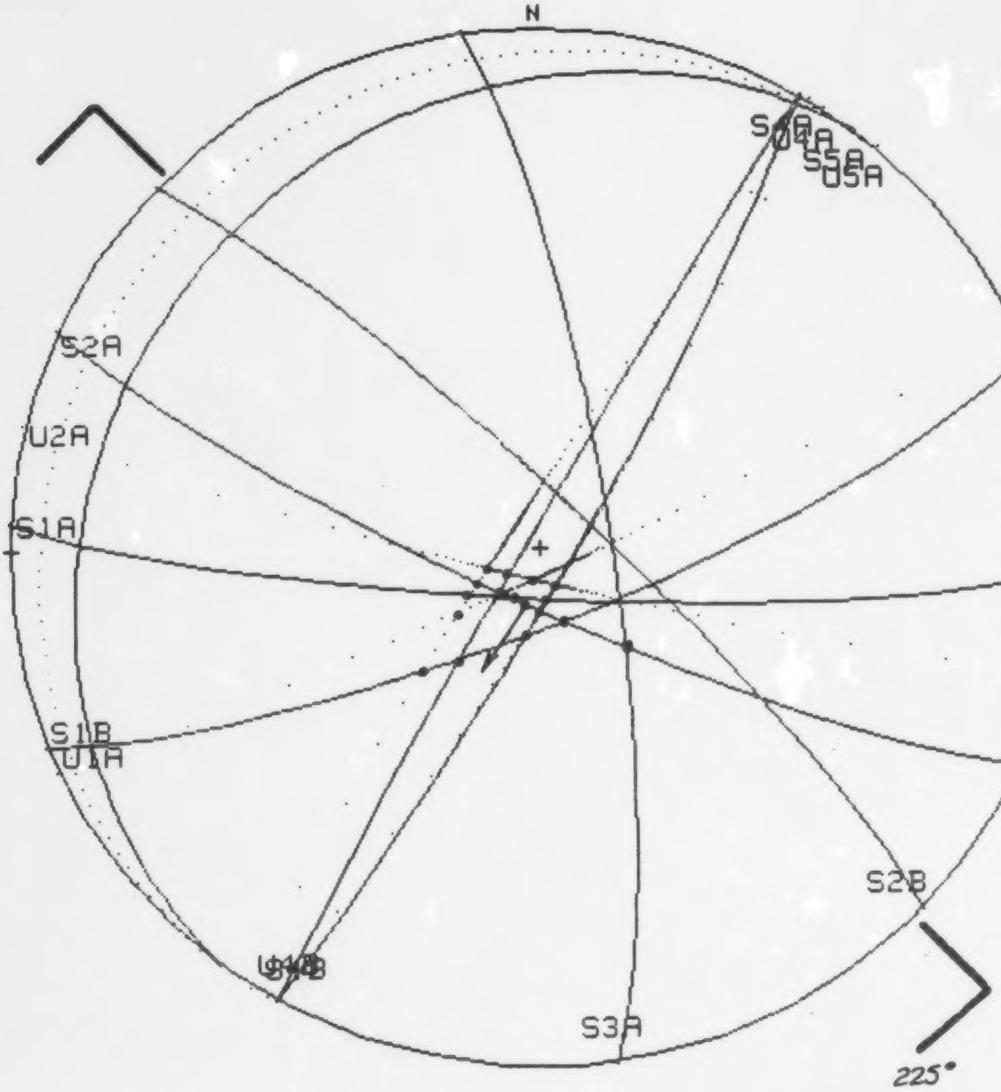


PLANE	AZI	DIP	NUMBER	C	PHI
DS1	170	82	10.0	0.0	30
D2A	222	88	41.0	0.0	30
D2B	200	88	24.0	0.0	30
D3A	282	79	21.0	0.0	30
D3B	100	72	10.0	0.0	30
D4A	300	90	28.0	0.0	30
D4B	317	87	17.0	0.0	30
D4C	140	52	7.0	0.0	30

M225-G

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

STRUCTURAL DOMAIN: GRANITES - MAIN

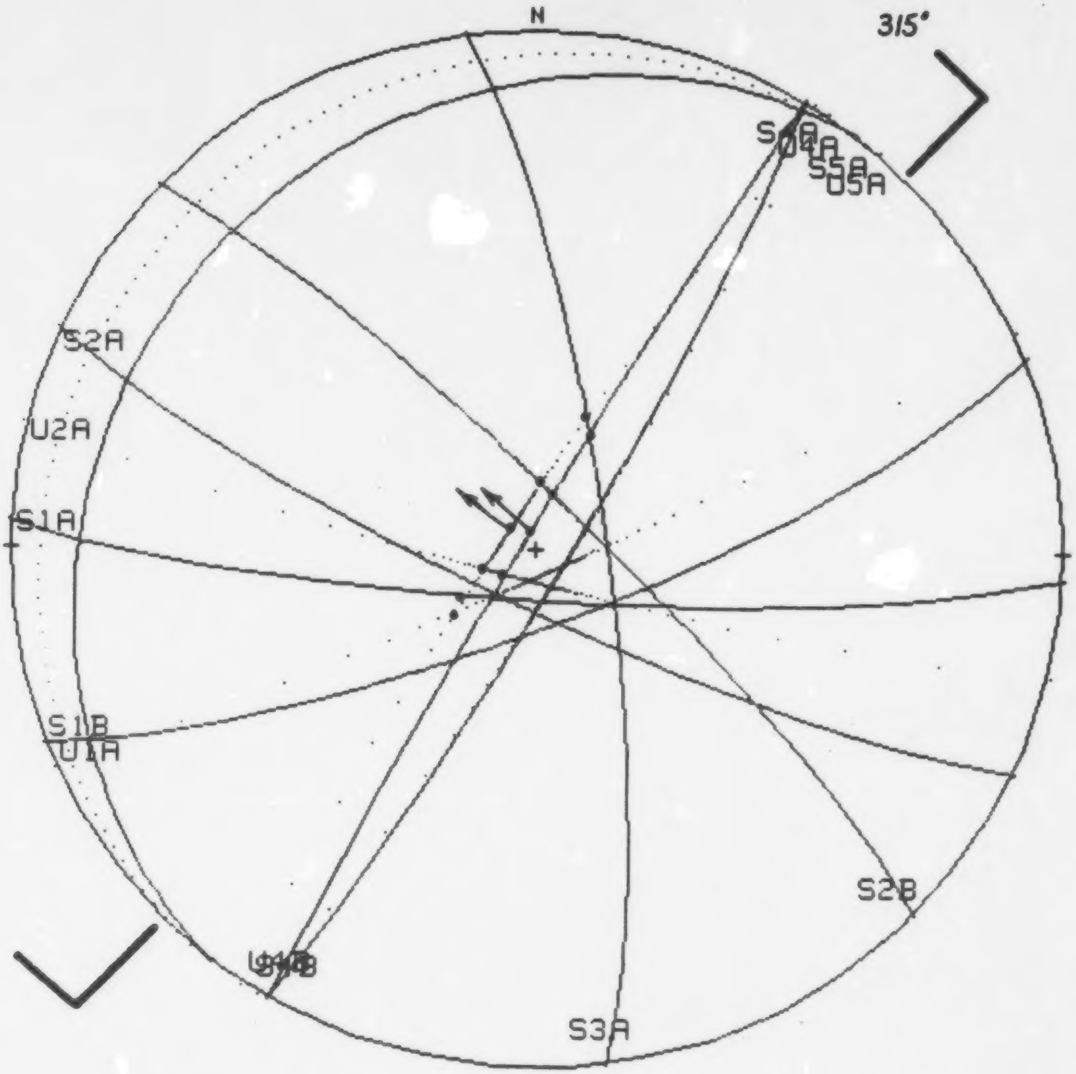


PLANE	AZI	DIP	NUMBER	C	PHI
S1A	183	82	42.0	0.0	30
S1B	158	78	42.0	0.0	30
S2A	205	81	21.0	0.0	30
S2B	044	82	16.0	0.0	30
S3A	082	79	26.0	0.0	30
S4A	300	88	33.0	0.0	30
S4B	120	85	31.0	0.0	30
S5A	307	18	5.0	0.0	30
U1A	155	86	17.0	0.0	30
U2A	194	85	46.0	0.0	30
U4A	303	85	17.0	0.0	30
U4B	121	85	17.0	0.0	30
U5A	310	09	5.0	0.0	30

M315-G

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

STRUCTURAL DOMAIN: GRANITES - MAIN

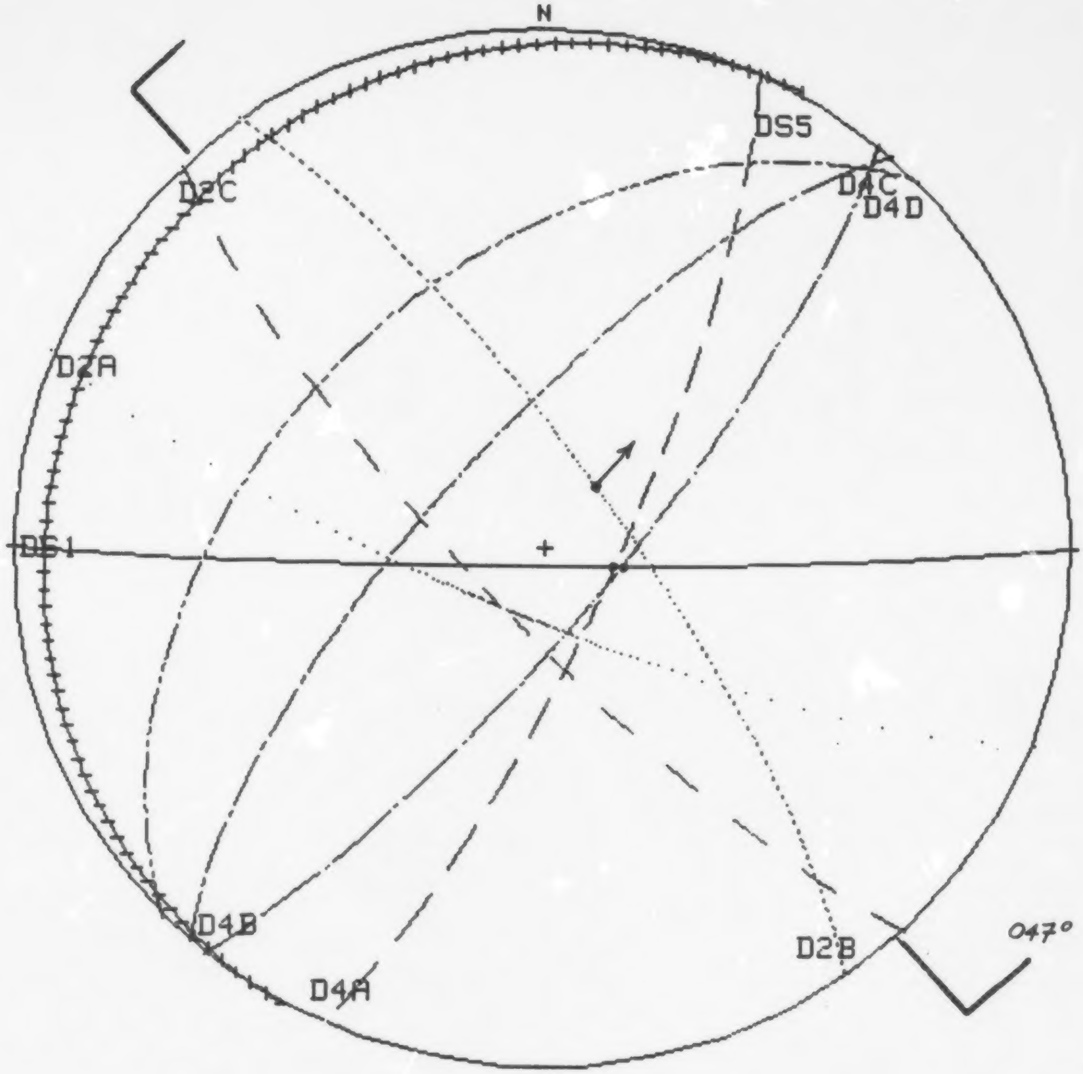


PLANE	AZI	DIP	NUMBER	C	PHI
S1A	183	82	42.0	0.0	30
S1B	158	78	42.0	0.0	30
S2A	205	81	21.0	0.0	30
S2B	044	82	16.0	0.0	30
S3A	082	79	26.0	0.0	30
S4A	300	88	33.0	0.0	30
S4B	120	85	31.0	0.0	30
S5A	307	18	5.0	0.0	30
U1A	155	86	17.0	0.0	30
U2A	194	85	46.0	0.0	30
U4A	303	85	17.0	0.0	30
U4B	121	85	17.0	0.0	30
U5A	310	09	5.0	0.0	30

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

B047-S

STRUCTURAL DOMAIN: SEDIMENTS - BZ

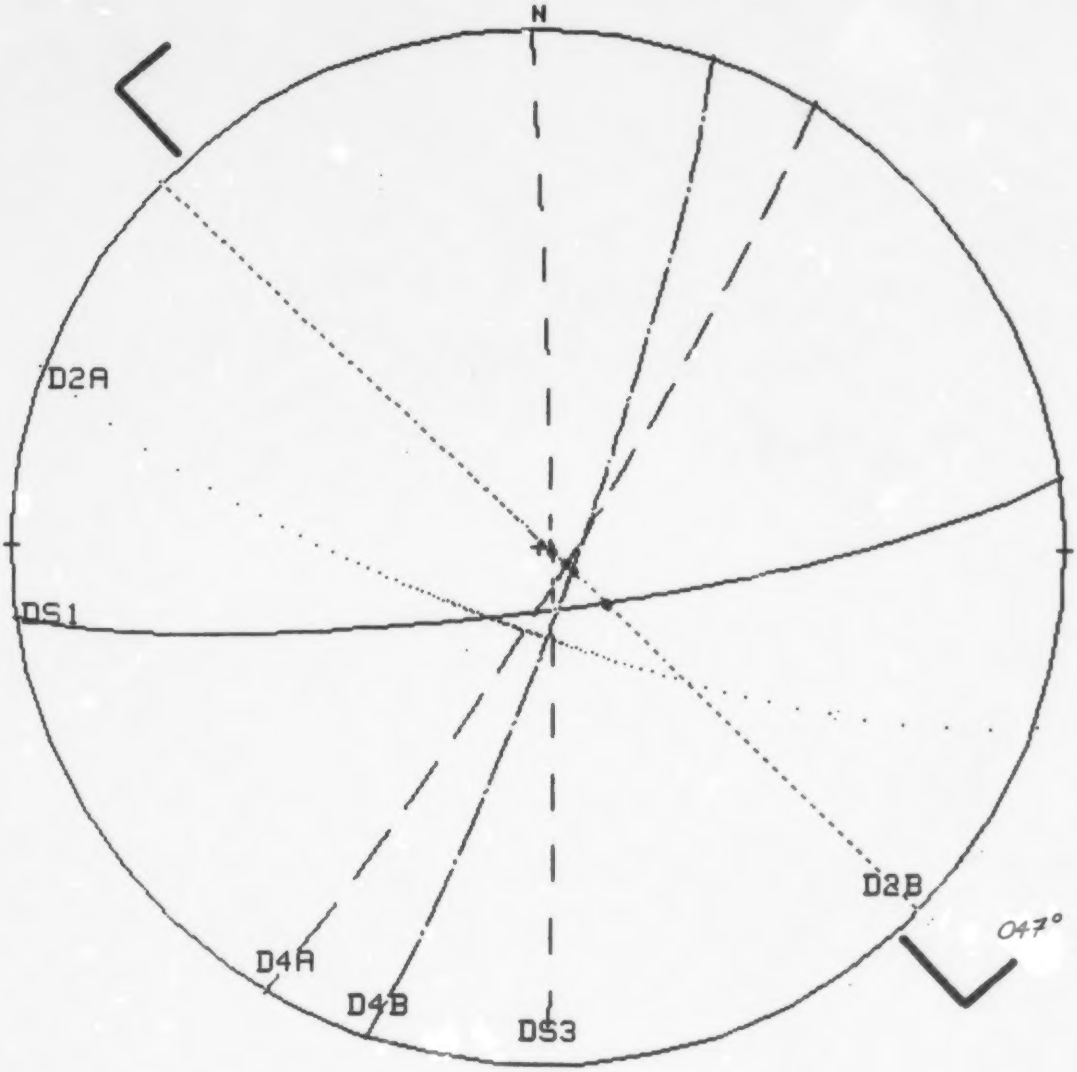


PLANE	AZI	DIP	NUMBER	C	PHI
DS1	180	87	21.0	0.0	30
D2A	202	79	13.0	0.0	30
D2B	055	78	8.0	0.0	90
D2C	227	79	7.0	0.0	30
D4A	114	79	18.0	0.0	33
D4B	129	79	15.0	0.0	30
D4C	311	73	16.0	0.0	30
D4D	315	47	7.0	0.0	30
DS5	299	08	3.0	0.0	30

B047- G

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

STRUCTURAL DOMAIN: BZ GRANITE

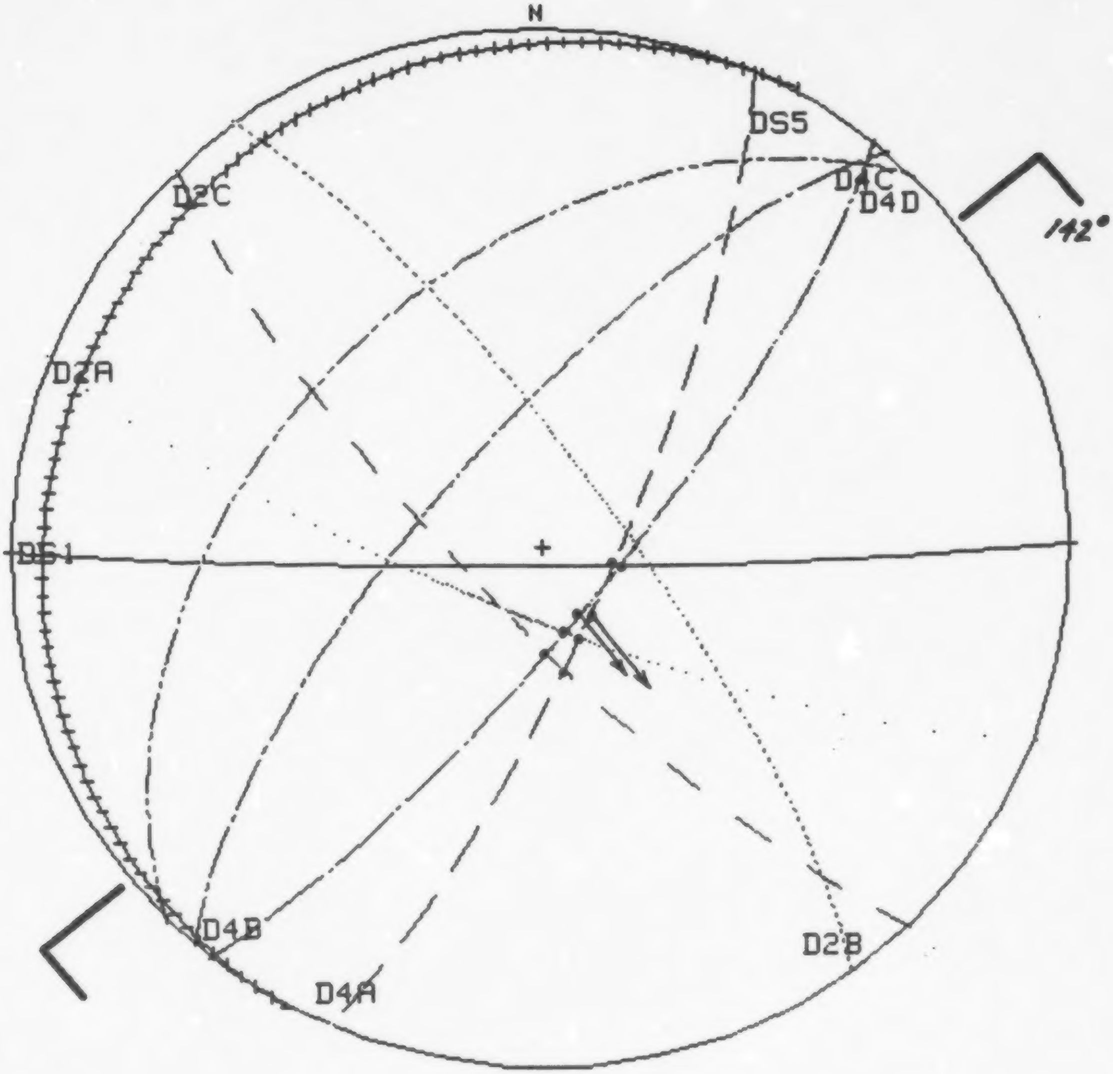


PLANE	AZI	DIP	NUMBER	C	PHI
DS1	172	80	21.0	0.0	30
D2A	200	77	13.0	0.0	30
D2B	044	89	1.0	6.0	30
DS3	089	88	10.0	0.0	30
D4A	121	85	9.0	0.0	30
D4B	109	84	5.0	0.0	30

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

B142-S

STRUCTURAL DOMAIN: SEDIMENTS - BZ

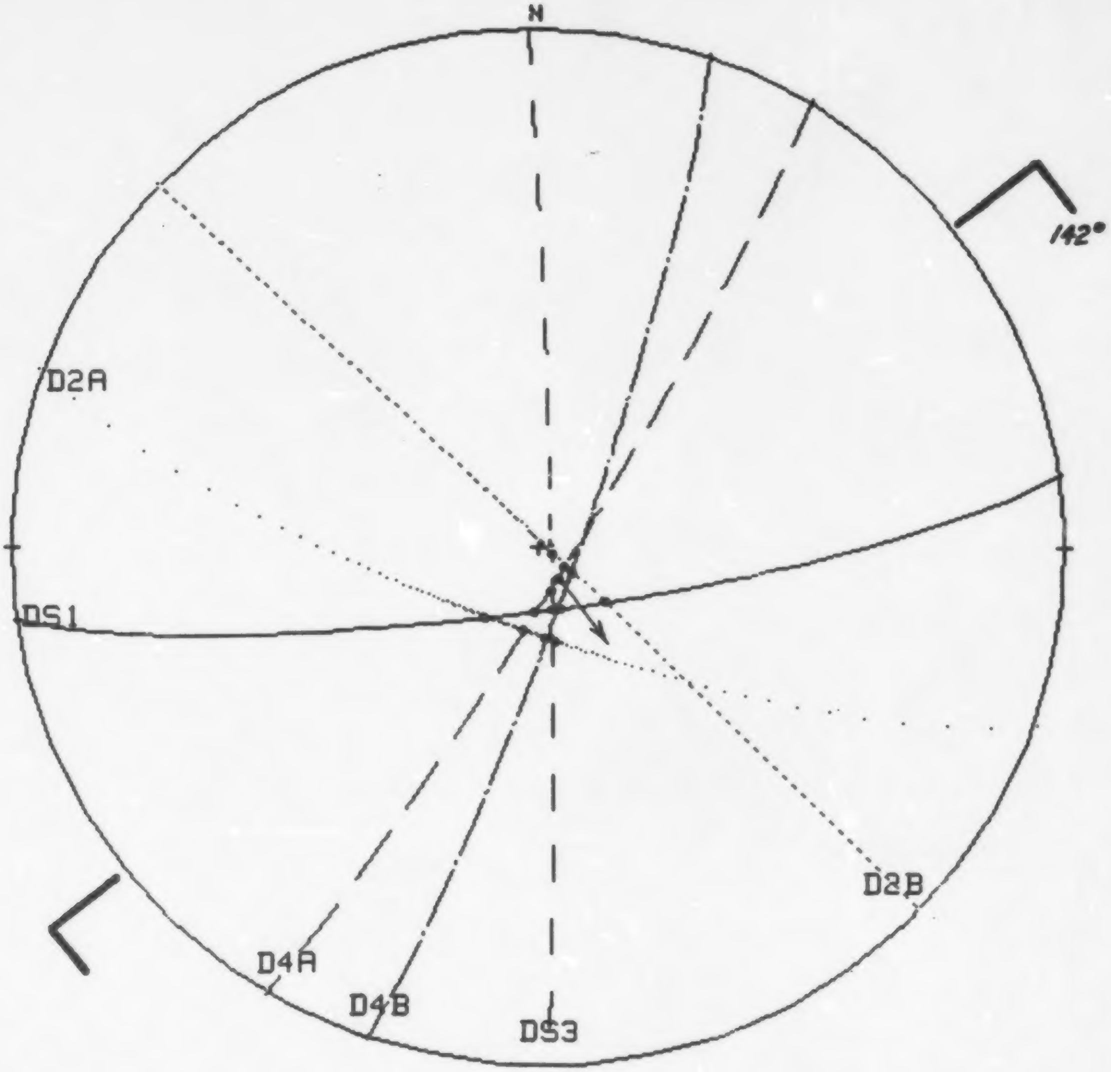


PLANE	AZI	DIP	NUMBER	C	PHI
DS1	180	87	21.0	0.0	30
D2A	202	79	13.0	0.0	30
D2B	055	78	8.0	0.0	90
D2C	227	79	7.0	0.0	30
D4A	114	79	18.0	0.0	30
D4B	129	79	15.0	0.0	30
D4C	311	73	16.0	0.0	30
D4D	315	47	7.0	0.0	30
DS5	299	08	3.0	0.0	30

B142-G

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

STRUCTURAL DOMAIN: BZ GRANITE

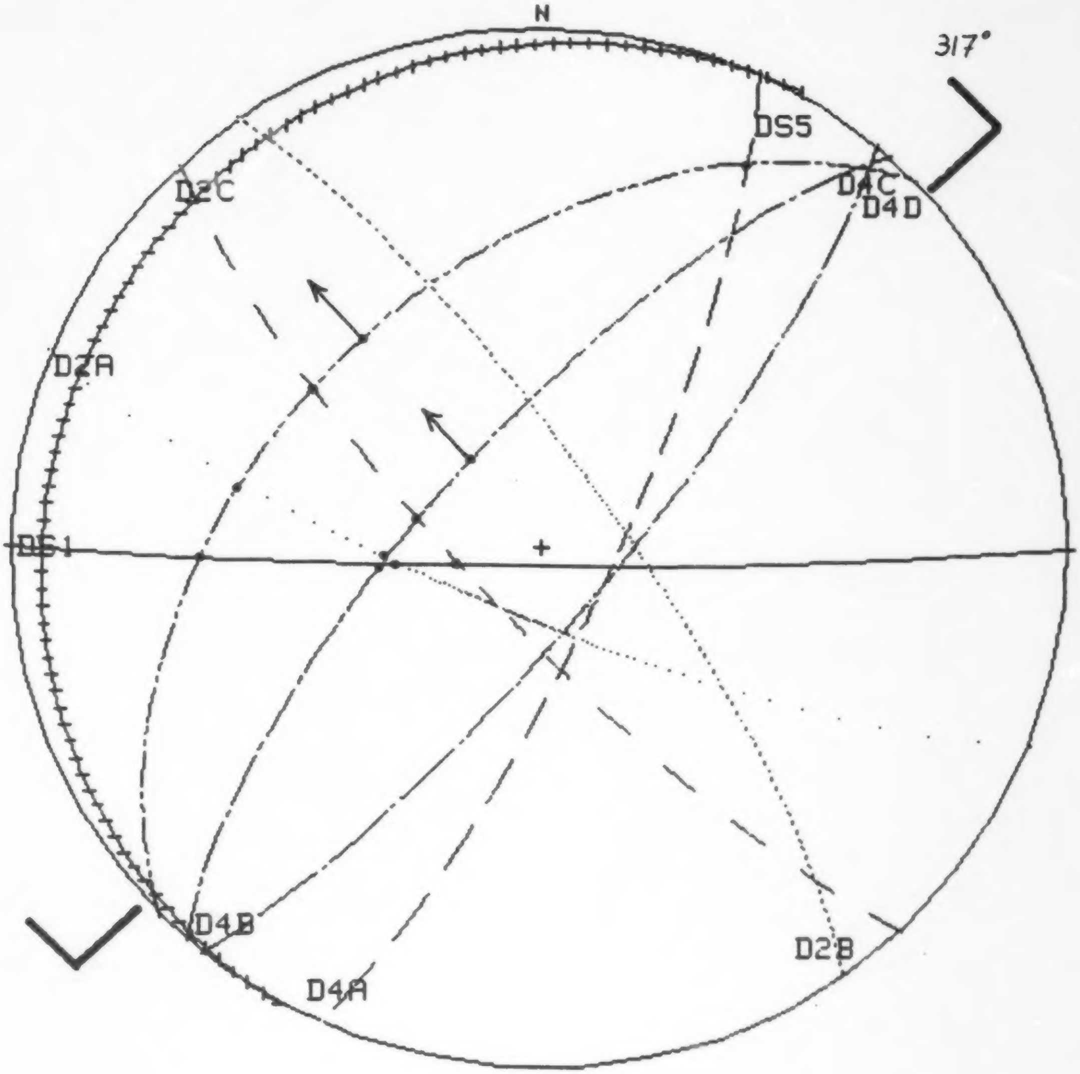


PLANE	AZI	DIP	NUMBER	C	PHI
DS1	172	80	21.0	0.0	30
D2A	200	77	13.0	0.0	30
D2B	044	89	1.0	6.0	30
DS3	089	88	10.0	0.0	30
D4A	121	85	9.0	0.0	30
D4B	109	84	5.0	0.0	30

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES

B317-S

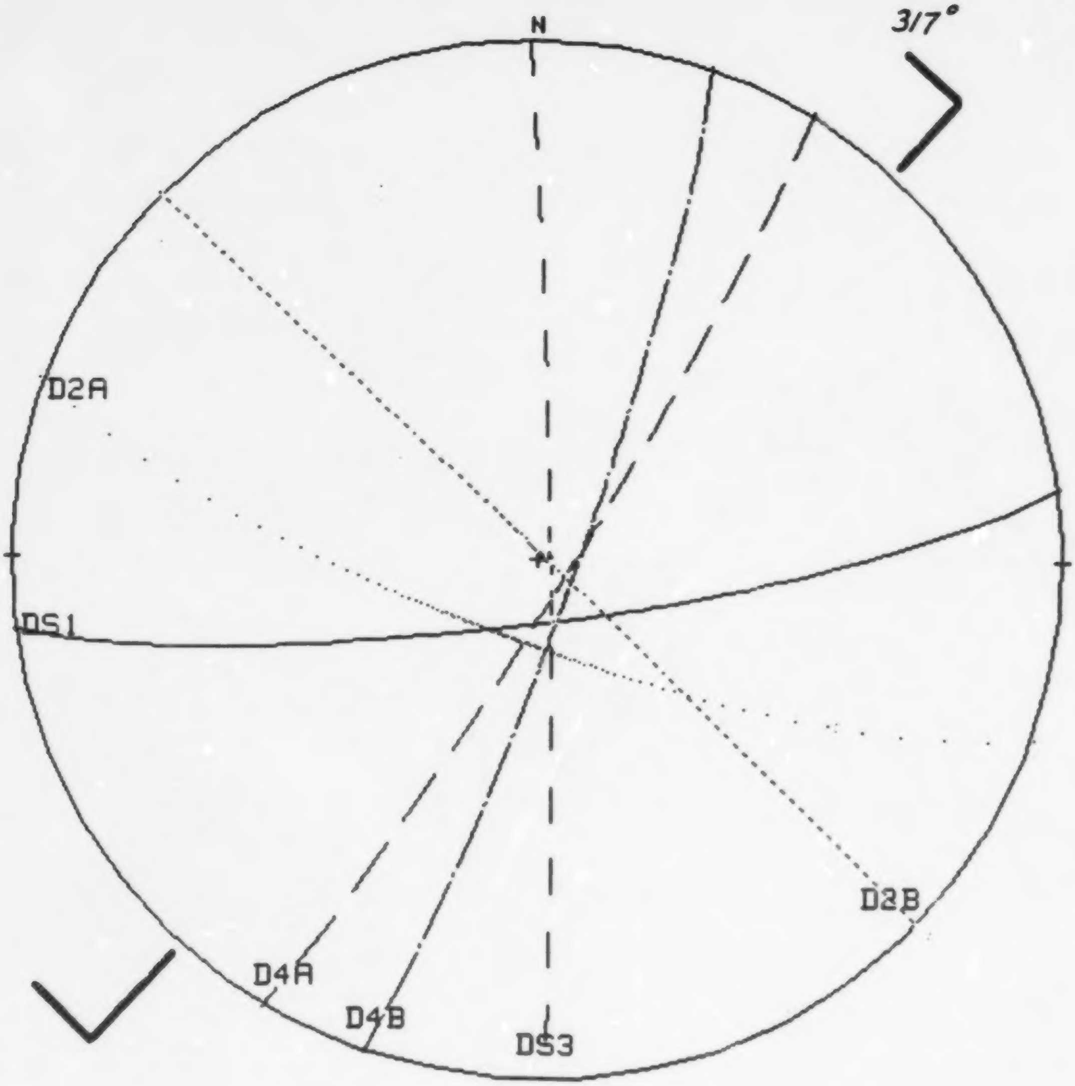
STRUCTURAL DOMAIN: SEDIMENTS - BZ



PLANE	AZI	DIP	NUMBER	C	PHI
DS1	180	87	21.0	0.0	30
D2A	202	79	13.0	0.0	30
D2B	055	78	8.0	0.0	90
D2C	227	79	7.0	0.0	30
D4A	114	79	18.0	0.0	30
D4B	129	79	15.0	0.0	30
D4C	311	73	16.0	0.0	30
D4D	315	47	7.0	0.0	30
DS5	299	08	3.0	0.0	30

GEOPLN - LOWER HEMISPHERE EQUAL AREA PROJECTION OF PLANES **B317-G**

STRUCTURAL DOMAIN: BZ GRANITE



PLANE	AZI	DIP	NUMBER	C	PHI
DS1	172	80	21.0	0.0	30
D2A	200	77	13.0	0.0	30
D2B	044	89	1.0	6.0	30
DS3	089	88	10.0	0.0	30
D4A	121	85	9.0	0.0	30
D4B	109	84	5.0	0.0	30

APPENDIX 2

GEOTECHNICAL ASSESSMENTS FOR OPEN PIT SLOPES

PITEAU ASSOCIATES, JULY 1989

PITEAU ASSOCIATES
GEOTECHNICAL AND
HYDROGEOLOGICAL CONSULTANTS

KAPILANO 100, SUITE 408
WEST VANCOUVER, B.C.
CANADA V7T 1A2
TELEPHONE (604) 926-8551
FAX 926-7286
TELEX 04-352896

DENNIS C. MARTIN
R. ALLAN DAKIN
ALAN F. STEWART
FREDERIC B. CLARIDGE
TADEUSZ L. DABROWSKI

Our file: 89-159

July 24, 1989

Mr. Gary Smith, Mine Superintendent
Rio Kemptville Tin Corporation
P.O. Box 6
East Kemptville, Nova Scotia
BOW 1Y0

Dear Gary:

Re: Geotechnical Assessments for Open Pit Slopes

Further to my site visit of July 3 and 4, 1989 and a number of telephone conversations, I am pleased to furnish the following proposal to provide geotechnical rock slope design services for the Rio Kemptville Tin Mine. It is understood that no rock slope design studies have been conducted to date and that the scope of our work would involve carrying out sufficient studies to arrive at slope designs for the ultimate pit. Approximately 15 to 20 years of reserves apparently remain, with ultimate pit slopes reaching an average height of about 100m.

The purpose of the site visit in the first week of July was to briefly review the geology, meet with mine personnel to discuss study requirements and evaluate what relevant geotechnical data could be obtained by mine geologists from the diamond drilling program that is to be undertaken from July to September 1989. In this regard, geotechnical core logging of mechanical rock properties was demonstrated to Claude Poulin so that the core from the upcoming drill program can be geotechnically logged at the same time as it is being lithologically logged. Geotechnical mapping procedures for mapping discontinuities in the pit walls were also demonstrated and a manual describing both core logging and structural mapping techniques was provided.

DESCRIPTION OF THE PROPOSED WORK

Based on the scope of work discussed above, the work can be divided into a number of tasks as follows:

1. Initial Site Visit

This task has already been completed, and involved reviewing mine geology, demonstrating core logging procedures and field mapping procedures to site personnel, examining the site to obtain an appreciation of general rock mass

...2

conditions and geotechnical parameters, etc. This aspect of the study involved two days on site.

2. Data Collection

It is anticipated that virtually all data collection, including core logging and geotechnical mapping, would be carried out by mine personnel. Core logging of BQ core would begin in the middle to latter half of July and would continue for about seven weeks (i.e. to early September). Geotechnical mapping and documentation of the pit walls would be initiated near the end of the drilling program and would likely take up to about three man weeks. While the core logging and mapping would be carried out essentially by mine personnel, it is important for Piteau Associates to carry out sufficient core logging and field mapping to gain a reasonable appreciation for the nature and behaviour of the rock mass (i.e. strength, orientation and nature of main discontinuity sets, etc.). This would involve a three to five day site visit that ideally would be scheduled to take place at the end of the drilling and core logging program, and at the start of the geotechnical mapping program. In this way, a limted amount of core could be logged by Piteau Associates before it is split for assaying, and further training of mine personnel in mapping procedures could be carried out. It is noteworthy that due to the generally strong nature of the rocks at the mine, laboratory strength testing is not felt to be required. Field index tests should be sufficient to estimate rock strength parameters necessary for the slope design studies. Other relevant information, such as plans, geologic sections, blasting data, etc. would be collected during the site visit.

3. Analysis and Design

All data collected would be compiled, processed and structurally analyzed using lower hemisphere projections to assess structural patterns and select structural domain boundaries. The structural data would also be reviewed with respect to location of possible major structural features and their implication on pit design. Results of geotechnical core logging would be compiled to determine the rock mass properties of the main rock types and the consistency of these properties in plan and at depth.

The results of the data analysis would be used to prepare a pit plan and representative sections showing the distribution of the various structural

...3

domain boundaries on the pit walls. Having divided the pit into structural domains, the next step would be to divide the ultimate pit into "design sectors", which are zones within which the rock mass behaviour and pit slope orientation are expected to be consistent. Kinematic analyses would be carried out for each design sector to determine the kinematically possible failure modes. Possible failures involving individual benches, interramp slopes and overall slopes would be identified and assessed. Appropriate stability analyses would be carried out.

Results of the structural analyses, kinematic analyses and stability analyses would be evaluated and a slope design prepared for each design sector. If necessary, alternative designs would be evaluated and possible methods of developing some slopes using remedial measures such as artificial support, controlled blasting, etc. would be assessed. Suggestions as to trial slopes, monitoring, and approach to bench development would be made if felt to be relevant.

4. Report Preparation

All of the above would be summarized in a report which documents procedures and summarizes all the data collection, structural analyses, stability analyses, slope design recommendations, etc. If required, a draft report would be prepared and forwarded to the mine for review and comments before the report is finalized.

5. Optional Report Presentation

At the option of the mine, a site visit could be made at the conclusion of the study to present the report and discuss the findings with mine personnel. Such a site visit would probably be most beneficial following preparation of the draft report, before it is finalized.

PERSONNEL

The project would be under the direction of Mr. A. Stewart. Mr. Stewart has already initiated the study by demonstrating core logging and structural mapping techniques to mine personnel who will carry out virtually all of the data collection. Mr. Stewart and a junior engineer from Piteau Associates would conduct all of the analyses and prepare the report. Piteau Associates welcomes any

...4

involvement by mine personnel in all aspects of the study, as such involvement helps to ensure that mine personnel fully understand the work being carried out, the analysis procedures and the results.

SCHEDULE AND COST ESTIMATES

As discussed above, the initial site visit was made on July 3 and 4, 1989. Core logging is expected to be conducted between about mid-July and September. Structural mapping, which would begin near the end of the core logging, is expected to take about three man weeks to complete. It is proposeod that Mr. Stewart visit the mine for three to five days at the end of the core logging/start of the structural mapping. Structural analyses, stability analyses, design and report preparation would be carried out immediately following the collection of the data and are expected to take about four weeks to complete.

The estimated time, professional services and direct costs for the various tasks of the project are summarized in Table I. The estimated cost ranges between $22,100 and $31,300. Task 1 has already been completed.

I hope the above is sufficient for your needs at this time. Should you have any questions or comments concerning this proposal, please do not hesitate to contact me.

Yours very truly,

PITEAU ASSOCIATES ENGINEERING LTD.

Alan F. Stewart, P.Eng.

AFS/ef

Enc.

TABLE I

SUMMARY OF ESTIMATED TIME AND COSTS

TASK	DESCRIPTION	PROFESSIONAL SERVICES			DIRECT COSTS	TOTAL COSTS
		Time (Days)		FEES		
		Stewart 600/Day	Junior Engineer 320/Day			
1	INITIAL SITE VISIT: Briefly review geology and engineering geology; inspect pit walls; demonstrate core logging and mapping techniques.	2	-	1,200	1,400^1	2,600
2	DATA COLLECTION: Core logging and structural mapping by mine personnel; limited core logging and structural mapping by A. Stewart; review and collection of other relevant data, reports, etc.	5-7	-	3,000 - 4,200	2,500 - 2,900^1	5,500 - 7,100
3.	ANALYSIS AND DESIGN: Compile data; conduct analyses; prepare slope design.	6-7	8-9	6,160 - 7,080	400^2	6,560 - 7,480
4.	REPORT PREPARATION: Prepare report summarizing the study.	6-8	6-8	5,520 - 7,360	1,920 - 2,960^3	7,440 - 10,320
5	OPTIONAL REPORT PRESENTATION: Present report findings at mine.	0-3	-	0 - 1,800	0 - 2,000^1	0 - 3,800
TOTAL		19-27	14-17	15,880 - 21,640	6,220 - 9,660	22,100 - 31,300

NOTES:
1. Includes airfare, vehicle rental, accommodation and meals.
2. Includes, computer, telephone, miscellaneous costs.
3. Includes drafting, word processing, report reproduction, miscellaneous.

APPENDIX 3

REPLACEMENT OF EDM THEODOLITE

RIO KEMPTVILLE TIN COMPANY, FEBRUARY 1991

March 20, 1991

PROBLEM:

REPLACEMENT OF PENTAX Px-06D EDM THEODOLITE SURVEY INSTRUMENT

Our current EDM theodolite was purchased in July 1985 as an upgrade over an optical theodolite using stadia measurements and office calculations. This unit has served our purposes well for more than 5 years, however it is approaching the end of its economic and possibly its serviceable life. (Greater than 5 years in a harsh environment is a good life.) Since mid 1989 this unit has required 7 bouts of repairs. The cost of rental replacement machines and machine repairs have a combined value of about $5,800.

Deficiencies of Current System:

1) during periods of alternating warm and cold weather, the internal build-up of condensation immobilizes the instrument several days until the condensation disappears.

2) the need for multiple distance measurements for a reliable distance (poor functioning electronics)

3) because of age, increased time to find rental replacement and time to effect repairs.

4) time consuming and possibly inaccurate manual data gathering.

5) time consuming and possibly inaccurate manual data entry in a computer data base

SOLUTION:

Option 1: Continue with current system
Option 2: Replace with another EDM theodolite system
Option 3: Replace with an electronic total station and data collector

Option 1: Continue with current system

This will tend to increase repair and rental machine costs, and do nothing to reduce the machine unreliability. There will be no time savings in doing routine field work, or increased field work, and loss of time and accuracy in manually entering data into a computer. It would be questionable if calculated month end volumes would be available, or reliable measurements could be taken when wanted for pit wall stability. These reasons make this option unacceptable.

Option 2: Replace with another EDM theodolite system

This option will remove the unreliability of the current system, but will not generate time savings in doing field work or computer data entry, or in calculating month end volumes. Depending on the type of EDM selected, costs are 70%-90% of the cost of a total station. Spending 70-90% of the value of a total station for only 50% of the benefit does not make this option acceptable.

Option 3: Replace with an electronic total station and data collector

This option would eliminate the unreliability of our current EDM theodolite and reduce maintenance/rental costs, and ensure reliable routine pitwall measurements for wall stability checks. Time savings will be generated with the data collector, resulting in faster, more error free field gathering of data and entry into a computer data base. This option will facilitate the gathering and entry of additional field data necessary to calculate month end measured volumes. Similarly, the down loading of the data collector will generate more computer access time. Such an instrument properly maintained should last 5-8 years. This is the most acceptable option.

RECOMMENDATION:

The Electronic Total Station with data collector best reduces the deficiencies of our current system, will improve the speed and accuracy of data collection and computer data entry, and greatly facilitate the calculation of month end measured volumes and pitwall stability measurements.

It is the recommendation of the Mine Department to purchase a Wild-Leitz TC-1000 integrated electronic total station and recording module from Leica Canada Inc. This is a medium weight, compact, 3 second measuring instrument with good range capabilities (1000-3000 M), and does not require external wires to connect the data collector. The warranty is for 2 years, parts and labour, and would be fully serviced from Dartmouth, Nova Scotia.

Over the period of August 24-November 28, 1989, the manufacturer's of 4 brands of total stations provided on-site demonstrations and left equipment on-site for trial periods.

The following factors were considered in the evaluation of the trial instruments:

1) Ability of the instrument to operate under various weather conditions, i.e: rain, fog, dust, snow, and cold.

2) Instrument precision and accuracy. The instrument must be accurate enough for control stations and stability control, as well as suitable for routine operations such as blast hole pickups/layouts. Our requirement is for an instrument capable of accurately measuring medium distances up to 2.0 km.

3) Ease of operation. Smooth physical operation with low maintenance. The data collector unit will facilitate quick storage of field data and speed down-loading into a computer.

4) Availability of parts and service offered by manufacturer's or dealers. We want to be sure of the availability of a replacement instrument in case of failure.

The accompanying memo illustrates the Mine Technician's comments on the operation of the equipment over the trial period.

MEMORANDUM

TO: JOHN DAVIS

FROM: ERNIE HENNICK

SUBJECT: OPERATOR COMMENTS
RE: ON-SITE USE OF TOTAL STATION
SURVEY EQUIPMENT

DATE: (OCTOBER 26, 1989) FEBRUARY 5, 1991

After an on-site demonstration by sales representatives from "Pentax", "Geodimeter", "Wild", and "Topcon" equipment, machines were made available for on site use and evaluations are as follows:

1. Make: PENTAX - PTS Total Station
    - When the instrument is turned off, the horizontal angle setting is lost.
    - Tangent screws and motion locks are reversed which took a while to get used to.
    - Keypad could be difficult to use in cold weather.
    - Only 2 measured values can be displayed at the same time.
    - Instrument worked well but did not seem to be of the same quality as the other two.

    Period of Usage: August 24, 1989 - September 8, 1989

2. Make: GEODIMETER - 420 Total Station

- The biggest problem I can see with the instrument is its size and weight.
- Instrument worked well and was easy to operate.
- Dual axis compensator made set-up and levelling fast.
- It has a large keypad and display screen.
- All 3 measured values are displayed at the same time.

Period of Usage: October 10, 1989 - October 13, 1989

3. Make: WILD - Theodolite T1000/Distomat DI1000

- Seem to take longer to physically manipulate the instrument than it does for the others.
- Only 2 measured values are displayed at the same time.
- Keypad is easy to use but could be difficult to use in the cold weather.
- Instrument is compact and light weight.
- REC Module System is good because it eliminates the need for external data collector and cable.

Period of Usage: October 16, 1989 - October 19, 1989

4. Make: TOPCON - GTS - 3C Total Station

- Measuring beam is very narrow.
- Demonstration instrument had no remote elevation or missing line function.
- A data collector was not provided.
- The instrument is approximately the same quality as a PENTAX total station.
- The instrument is reasonably light.
- Foot screws and tangent screws work very smoothly.
- Battery life seems to be very good.
- Keys are conveniently located and work well.

Period of Usage: November 15, 1989 - November 28, 1989

Ernie Hennick,
Mine Technician

EH/s

TOTAL STATION FEATURES

Manufacturer:	Pentax Canada Inc.	Pentax Canada Inc.
Model	PTS - II 20F	PTS - III 05
Inst. Wt.		
Battery Wt.		
Total Wt.	6.9 kg.	6.9 kg.
DIST. MEASURE.		
ord. haze, 1 p.	750 m.	1800 m.
lite haze, 1 p.		
no haze, 1 p.	1000 m.	2000 m.
Accuracy:	(5 mm + 3 ppm) m.s.e.	(5 mm + 3 ppm) m.s.e.
Least count/time		
Normal/time	1 mm./ 5 sec.	1 mm./ 4 sec.
Tracking/time	10 mm./ 1 sec.	10 mm./.6 sec.
Light source	Infra-red	Infra-red
Beam Divergence		
ANGLE MEASURE.		
Least count	20 " / 10 "	5 " / 1 "
Accuracy:	10 "	3 "
Min. focus dist.	1.4 m.	1.4 m.
DATA COLLECTOR	DC - 1Z	
Memory Cap.	32 kb / 1000 pts.	
Temp. Range	-20 C, +50 C	
Wt.	0.66 kg.	
Interface	RS - 232C	
Power Supply	4 AA, 100 Hrs.	
Service Center	Dartmouth, Toronto	
Warranty	2 yrs. parts & labor	
Training	1 Day onsite, N/C	

TOTAL STATION FEATURES

03/13/91

Manufacturer:	Geodimeter of Canada
Model	400 Canadian
Inst. Wt.	
Battery Wt.	
Total Wt.	7.9 kg.
DIST. MEASURE.	
ord. haze, 1 p.	1600 m.
lite haze, 1 p.	n/a
no haze, 1 p.	n/a
Accuracy:	(5 mm + 5 ppm) m.s.e.
Least count/time	
Normal/time	1 mm. / 5 sec.
Tracking/time	10 mm. /.4 sec.
Light source	Infra-red GaAs diode
Beam Divergence	25 cm / 100 m.
ANGLE MEASURE.	
Least count	3 "
Accuracy:	Std. Dev.
Min. focus dist.	1.3 m.
DATA COLLECTOR	GEODAT 400
Memory Cap.	1500 pts.
Temp. Range	-20 C, +50 C
Wt.	0.65 kg.
Interface	RS - 232C
Power Supply	Main battery
Service Center	Toronto, Ont.
Warranty	2 yrs. parts & labor
Training	1 Day onsite, N/C

TOTAL STATION FEATURES

Manufacturer:	Leica Canada Inc.	Leica Canada Inc.
Model	Wild TC1000 / Rec. mod.	Wild T1000 & DI1001
Inst. Wt.	5.5 kg.	5.5 kg.
Battery Wt.	1.1 kg.	1.1 kg.
Total Wt.	6.6 kg.	6.6 kg.
DIST. MEASURE.		
ord. haze, 1 p.	1000 m.	500 m.
lite haze, 1 p.	2000 m.	800 m.
no haze, 1 p.	3000 m.	900 m.
Accuracy:		
Least count/time		
Normal/time	3 mm.+ 2 ppm./4 sec.	5 mm.+ 5 ppm./1.5 sec.
Tracking/time	5 mm.+ 2 ppm./1-2 sec.	10 mm.+ 5 ppm./<1. sec.
Light source	Infra-red (0.85 m.)	Infra-red (0.85 m.)
Beam Divergence	70 cm / 1000m.	40 cm / 1000m.
ANGLE MEASURE.		
Least count	3 "	3 "
Accuracy:	Std. Dev.	Std. Dev.
Min. focus dist.	1.7 m.	1.7 m.
DATA COLLECTOR	REC. MOD. GIF 12	REC. MOD. GIF 12
Memory Cap.	64 kb / 2000 pts.	64 kb / 2000 pts.
Temp. Range	-20 C, +50 C	-20 C, +50 C
Wt.	0.070 kg.	0.070 kg.
Interface	RS - 232C	RS - 232C
Power Supply	Theodolite, no cables	Theodolite, no cables
Service Center	Halifax, N.S.	Halifax, N.S.
Warranty	2 yrs. parts & labor	2 yrs. parts & labor
Training	1 Day onsite, N/C	1 Day onsite, N/C

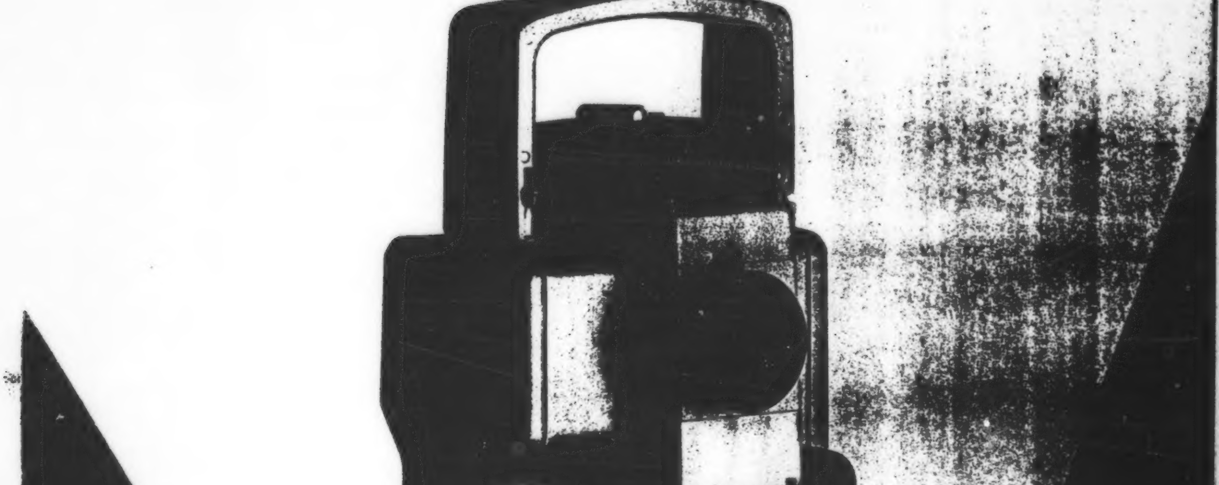
TOTAL STATION FEATURES

Manufacturer:	Topcon	Topcon
Model	3 B	3 C
Inst. Wt.	5.2 kg.	5.2 kg.
Battery Wt.	1.0 kg.	1.0 kg.
Total Wt.	6.2 kg.	6.2 kg.
DIST. MEASURE.		
ord. haze, 1 p.	1400 m.	1000 m.
lite haze, 1 p.	1800 m.	1200 m.
no haze, 1 p.	2000 m.	1400 m.
Accuracy:	(5 mm + 3 ppm) m.s.e.	(5 mm + 3 ppm) m.s.e.
Least count/time		
Normal/time	1 mm./ 4 sec.	1 mm./ 4 sec.
Tracking/time	10 mm./.6 sec.	10 mm./.6 sec.
Light source	Infra-red	Infra-red
Beam Divergence		
ANGLE MEASURE.		
Least count	1 " / 5"	1 " / 5"
Accuracy:	2 "	5 "
Min. focus dist.	1.5 m.	1.5 m.
DATA COLLECTOR	FC - 1	FC - 4
Memory Cap.	60 kb / 800 pts.	60 kb / 800 pts.
Temp. Range	-20 C, +50 C	-20 C, +50 C
Wt.	0.70 kg.	0.70 kg.
Interface	RS - 232C	RS - 232C
Power Supply	2 Handle Batteries	2 Handle Batteries
Service Center	Halifax, N.S.	Halifax, N.S.
Warranty	2 yrs. parts & labor	2 yrs. parts & labor
Training	1 Day onsite, N/C	1 Day onsite, N/C

TACHYMAT™ Wild TC1000 · TC1600

ELECTRONIC TOTAL STATIONS WITH REC MODULE

WILD®
HEERBRUGG



WILD TC1000
WILD TC1600

TWO TOTAL STATIONS WITH OUTSTANDING PERFORMANCE FEATURES

W

Well-matched, compact system for angle and distance measurement, simultaneous data storage with REC module.

I

Intervals one second to record in tracking mode, flexible recording format.

L

T

Touch the ALL key once to measure and record angle and distance.

O

Options available for TC1000 and TC1600:

- Keyboard and displays face 1, slot for REC module face 2.
- Keyboard and displays both faces.

T

Transport: Compact, handy, lightweight. Weighs only 5.5 kg (12 lb).

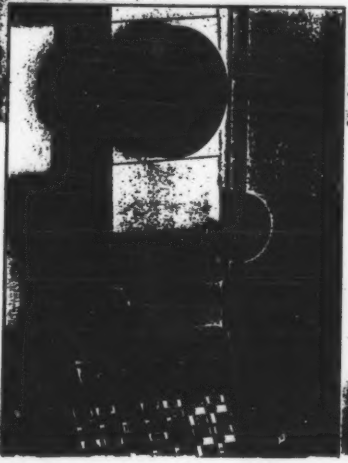
A

Angle-measuring accuracy to DIN 18723; TC1600: 1.5" TC1000: 3".

Single-prism range 2 km. Built-in EDM, standard deviation 3 mm + 2 ppm.

TC1600 with built-in coordinate-geometry functions: Computation in the field of tie distance, resection, area, setting-out elements, etc.

Absolute angle-scanning system, instantly ready for use. No time wasted on initialization.



Ergonomic form and layout of controls. Both total stations are available either with a control panel [illegible] displays and colour-coded keyboard [illegible]

Low power consumption: Even the small plug-in battery is enough for about 250 combined angle and distance measurements.

D

Display of recorded data: interchangeable plug-in REC module, capacity about 500 data blocks.

Measure and record angles and distance at the touch of a single key.
The interchangeable REC module can store about 500 data blocks.
Both total stations also have an interchangeable internal battery.

For practically any task:

Control surveys
Traversing
Triangulation
Trigonometric heighting

Engineering surveys
Deformation surveys
Industrial surveying
On-line computer link

Detail surveys
Cadastral surveys
Topographic surveys
Utilities surveys
Open-cast mines

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Large, easy-to-use, practical colour-coded keyboard.

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on.

Telescope: powerful, coaxial. Single line-of-sight for angle and distance measurement.

Intelligently located cable socket in fixed base, for connection of data terminal and external battery. Cable does not inhibit instrument movement.

On-line computer control: Both total stations are suitable for on-line control.

Numeric input also possible, e.g. point number and coded data.

TC1000:
Economy model with just the right level of accuracy and the right number of functions for day-to-day survey work.

TC1600:
High-performance model, with higher accuracy, more functions, more built-in computing facilities.

ANGLES, DISTANCE, AND REDUCTION AT THE TOUCH OF A SINGLE KEY

Ideal combination of angle and distance measurement

In the **Wild TC1000** and **TC1600**, the systems for measuring angles and distance, and the functions for reduction and recording are compactly integrated. Weighing only 5.7 kg (13 lb) including the internal battery, this equipment can simultaneously measure and record angles and distance up to 5 km (3 mi) in just four seconds.

Switch on and measure

Position-coded circles form the basis for the absolute electronic angle-measuring system of the **TC1000** and **TC1600**. They relieve the user of time-wasting initialization, because the instrument is instantly ready to measure. Angle measurement is continuous; the display is immediately updated as soon as you turn the telescope.

You can reset the horizontal circle to 0 or to any other azimuth by keyboard input and measure the horizontal angle clockwise or counterclockwise.

Outstanding angle-measurement accuracy

The standard deviation of the mean of observations on both telescope positions is **1.5″ (0.0005 gon) for the TC1600** and **3″ (0.001 gon) for the TC1000.**

Because of automatic compensation for circle eccentricity the **TC1600** also provides extremely accurate single-face measurement.

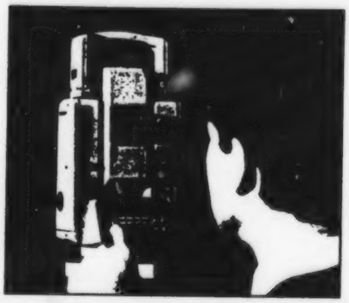
Measure and record as soon as you set up

As soon as you switch on your **TC1000** or **TC1600**, its absolute angle-scanning system and the powerful built-in EDM unit are ready for measurement. And just four seconds later they give you distance and reduced values. Touch the ALL key and the instrument measures angles and distance, and records them complete with the point number.

Up to 2 km single-prism range

The EDM unit of the **TC1000** and **TC1600** measures distance up to 5 km through the instrument's coaxial telescope. In average atmospheric conditions, a single reflector prism is all you need to measure distance up to 2 km (1¼ mi) with an **accuracy of 3 mm + 2 ppm.** For long range and poor weather conditions, the DIL repeat-measurement mode automatically ensures the same accuracy.

For setting-out, both total stations have a **tracking mode** with one-second updates of displayed values and an accuracy of 5 mm + 2 ppm. If required, these distances and their angles can be reduced and recorded.



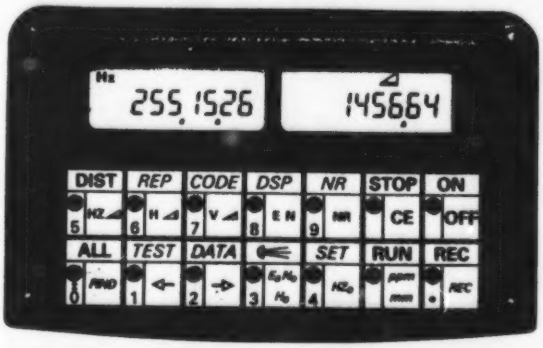
TC1000 and TC1600: Unity and functional diversity

	TC1000	TC1600
Pairs of displayed values:		
V angle, slope distance	●	●
Hz angle, horizontal distance	●	●
Height, height difference	●	●
Easting, northing	●	●
Point number	●	●
Hz angle, V angle		●
Setting-out difference		●
Coordinate-geometry results		●
ALL key	●	●
REM input of values		●
Coordinate-geometry functions		●
Instant readiness to measure	●	●
Computation of coordinates	●	●
REC module	●	●

Reliable, unequivocal design of controls

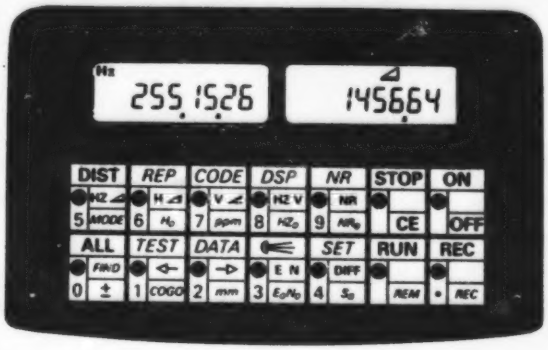
On the colour-coded keyboard you can call up practically any typical day-to-day task, including distance measurement and data recording, at the touch of a single key.

And you can input any essential **numeric information** such as point number, station coordinates etc. directly on the keyboard. To let you see better in the dark, the displays can be backlit.



TC1000

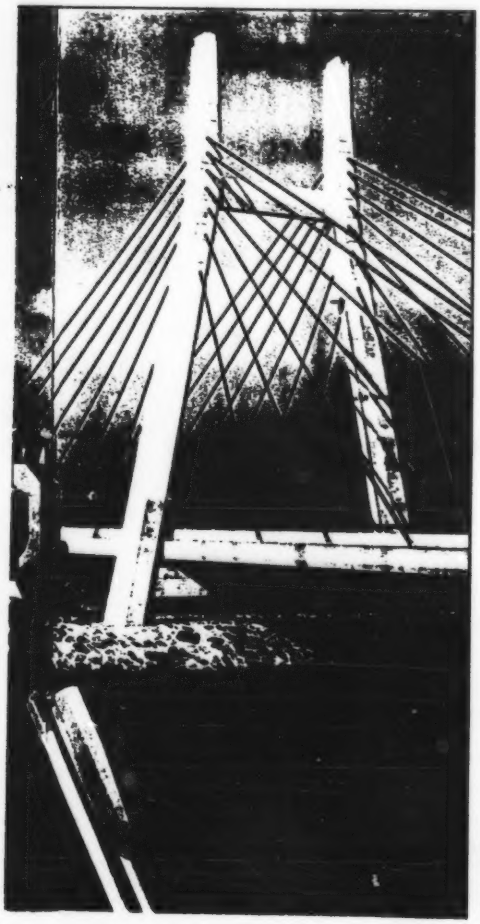
255° 15' 26"
1456.64 ft



TC1600

255° 15' 26"
1456.64 ft

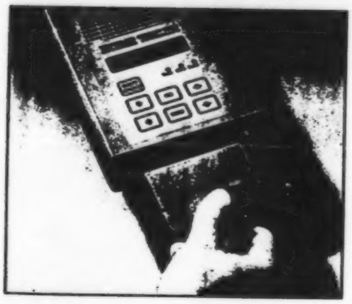
These are the two control panels: **TC1000 (above), TC1600 (below).** They let you control all the instrument's functions. The practice-tested design and layout are the best protection against false manipulation and make your work extremely efficient.



Both Wild models TC1000 and TC1600 are available without insert for a REC module. Instead, they may be used with a Wild GRE3/ GRE4 data terminal, for which there is a particularly wide choice of PROFIS software for programmed measurement

RECORD

The TC1000/TC1600 system has all the features you need to record measurements and other data, and process them in the field.



GIF10/GIF12 data reader

The GIF10 is an universal interface between REC module and computer, peripheral equipment, or another REC module. Use a GIF10 to display, copy, or delete data, to transfer them to a computer, and for on-line data input to the REC module.

The GIF12 is the ideal interface for on-line data transfer between the REC module and an IBM PC or compatible computer which runs under MS-DOS. See brochure G1 373 e.

GRM10 plug-in REC module, the most economical way to record and store data

Instead of a second control and display panel on face 2, **Wild TC1000** and **TC1600** total stations are available with a slot for a plug-in Wild GRM10 REC module that takes only a few seconds to insert or take out. The REC module can store about 500 data blocks. Use as many modules as you need to boost the **memory to any size you want.** Search and display functions simplify the display of recorded data on the total station.

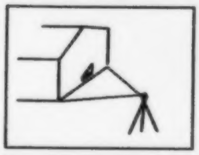
The REC module weighs a mere 70 g (2 oz) and is suitable for mailing.

The TC1600 with built-in programs for coping efficiently with routine tasks

These programs ensure the most effective professional field use of the TC1600. Bidirectional interchange of measured and computed data stored in the REC module makes efficient use of these built-in coordinate-geometry functions.

COMPUTE

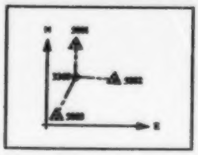
The available programs include:



TC1600: Coordinate-geometry functions

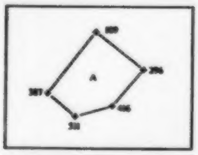
Manual coordinate input

Computation of tie distance



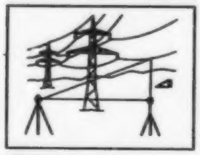
Resection

Orientation of horizontal circle



Computation of area

Setting-out



TC1000 and TC1600: Computing programs

Determination of the height of objects

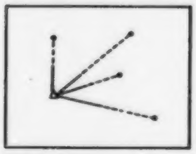
Target-point coordinates

PROGRAMMED SURVEYING

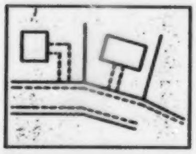
Unlimited possibilities with a Wild GRE3 or GRE4 data terminal and free PROFIS software

Wild TC1000/TC1600 and a GRE3 or GRE4 data terminal, the most efficient comination of all

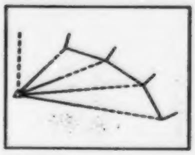
A few typical examples of PROFIS:



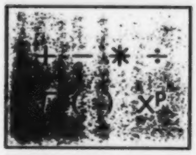
Free-station survey



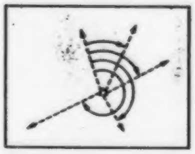
Plan-plotting program for A3 plotter



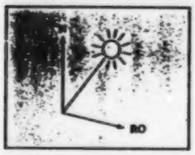
Instant computation of setting-out elements and building alignment



Computation of coordinates, pocket-calculator functions

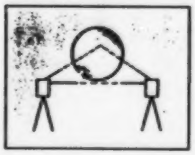


Automatic checking of horizontal angles and sets of directions



Determination of azimuth by sun sights

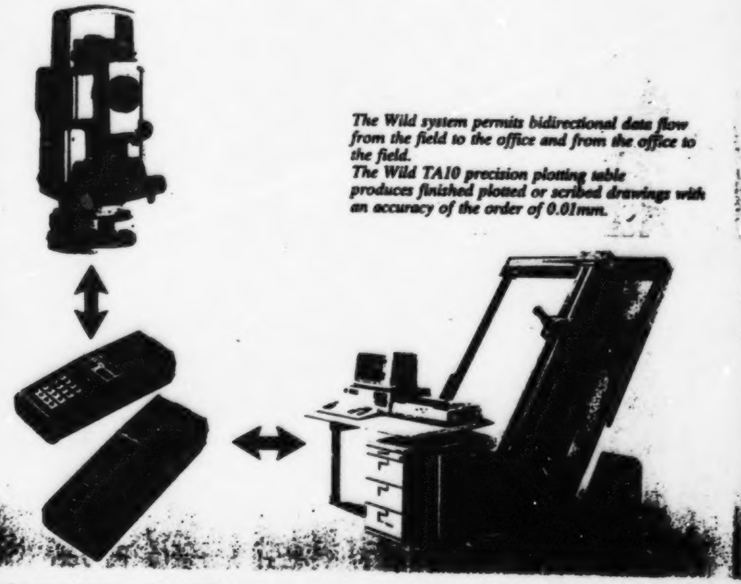
Computation of easting, northing, and height



Remote measurement (mini-RMS) using two or more instruments on-line to a PC

Well over a thousand of these weatherproof data terminals with 64 kbyte memory are in use worldwide. In conjunction with PROFIS software, they ensure maximum efficiency for coping with extremely complex computations. The BASIC module available for both models is freely user-programmable.
See brochure G1 369 e.

Simply touch the ALL key to measure and record at the same time. With its perfected surveying functions, the Wild TC1000/TC1600 helps you cope with complex tasks in a minimum of time.



The Wild system permits bidirectional data flow from the field to the office and from the office to the field.
The Wild TA10 precision plotting table produces finished plotted or scribed drawings with an accuracy of the order of 0.01mm.

WILD TC1000 AND TC1600: TECHNICAL DATA

Angle measurement	continuous absolute encoder	
Updates	0.1 s to 0.3 s	
Units	360° sexagesimal 360° decimal 400 gon 6400 mil	
	TC1600	**TC1000**
Smallest unit displayed	1", 0.0001°, 0.0001 gon, 0.001 mil	1", 0.0005°, 0.001 gon, 0.01 mil
Standard deviation to DIN 18723 (mean of pointing in both telescope positions)	Hz: 1.5" (0.0005 gon) V: 1.5" (0.0005 gon)	3" (0.001 gon) 3" (0.001 gon)
Automatic index	pendulum compensator	
Working range	±3' (±0.1 gon)	
Setting accuracy	±1" (±0.0003 gon)	
Telescope	coaxial, erect image	
Magnification with standard eyepiece	30×	
Objective aperture	42 mm	
Shortest focusing distance	1.7 m	
Field of view at 1000 m	27 m	
Focusing	coarse and fine	
Tilting range	fully transiting	
Displays	2 LCDs both faces; each display with sign, 8 figures, decimal point, flags and symbols to guide users	
Keyboard	weatherproof, 14 multiple-function keys	
Contact pressure	30 g	
Distance measurement		
Standard deviation		
Normal measurement	3 mm + 2 ppm, time needed 4 s	
Repeat measurement	3 mm + 2 ppm, time needed 3 s	
Tracking	5 mm + 2 ppm, time needed 1 s to 2 s	
Signal attenuation	automatic	
Breaks in beam	result not affected	
Range	**TC1000 and TC1600**	

Number of Wild circular prisms	Atmospheric conditions poor[1]	average[2]	excellent[3]
1	1.0 km	2.0 km	2.5 km
3	1.2 km	2.8 km	3.5 km
7	1.4 km	3.5 km	4.5 km
11	1.6 km	4.0 km	5.5 km

[1] Strong haze, visibility about 3 km; or strong sunlight, severe heat shimmer
[2] Light haze, visibility about 15 km; or moderate sunlight, slight heat shimmer
[3] Overcast, no haze, visibility about 30 km, no heat shimmer

Carrier wave	0.850 µm infra-red
Scale correction	−399 ppm to +399 ppm, 1 ppm steps
Prism constant	−999 mm to +999 mm, 1 mm steps
Automatic corrections	Eccentricity of Hz and V circles (TC1600 only) Horizontal-collimation error Vertical-index error Earth curvature and refraction
Two models	2 keyboards, displays both faces or keyboard and displays face 1, slot for REC module face 2
Data	displayed in pairs (see page 5)
Data recording	REC module • CMOS memory • Capacity 16 kbyte or about 500 data blocks • Dimensions 74 mm × 60 mm × 10 mm (3" × 2½" × ⅜") • Weight 70 g (2 oz) or GRE3/GRE4 data terminal

Power supply	12 V DC
Power consumption	
Angle measurement only:	about 0.06 A (excluding backlight to display)
incl. distance measurement:	about 0.4 A
Automatic power-off	about 3 minutes after last keyboard input
Plug-in battery GEB77	12 V, 2 Ah, NiCd, rechargeable
Fuse	FST 5020, T2.5 A, 5×20
Small battery GEB70	12 V, 2 Ah, NiCd, rechargeable
Fuses	FST 5020, T2.5 A, 5×20
Large battery GEB71	12 V, 7 Ah, NiCd, rechargeable
Fuses	FST 5020, T2.5 A, 5×20

Operating life of batteries (between charges)

	GEB 77	GEB 70	GEB 71
Approximate number of angle and distance measurements	250	1000	3500

Battery chargers	
GKL12	for GEB 77 and GEB 70
GKL14	for GEB 71
Hight of tilting axis above tribrach dish	196 mm (as T2, T1000, T1600, T2000)
Levels (sensitivity per 2 mm)	
Spherical level in tribrach	8'/2 mm
Tubular level in theodolite	30"/2 mm
Optical plummet (in tribrach)	focusable
Magnification	2×
Focus	fully adjustable
Temperature range	
Measurement	−20°C to +50°C (−4°F to +122°F)
Storage	−40°C to +70°C (−40°F to +158°F)
Weight	
Instrument without tribrach or battery	5.5 kg (12 lb)
GEB77 plug-in battery	0.2 kg (7 oz)
GDF22 tribrach	0.9 kg (2.1 lb)
Case	3.9 kg (8.6 lb)
GEB70 small battery	0.9 kg (2.1 lb)
GEB71 large battery	3.0 kg (6.6 lb)

WILD LEITZ

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Illustrations, descriptions, and technical data are not binding and may be changed without notice.

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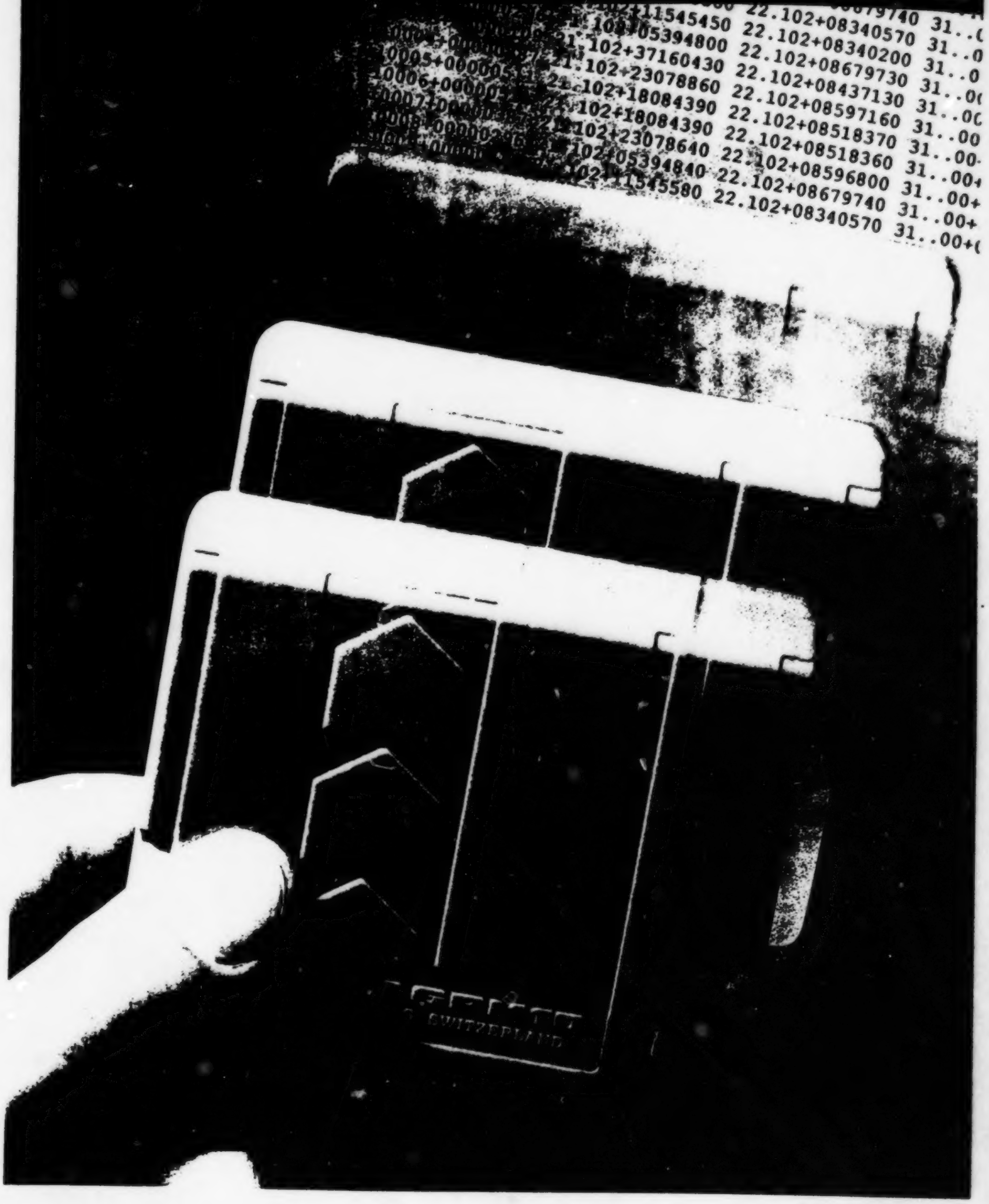
WILD GRM10 · GIF10 · GIF12



REC module • data reader • interface

Leica

2.

Measure

The modular Wild system

Use the Wild REC module for programmed field surveys. The system based on this module automates the flow of data, from preparatory work on the project all the way to the finished plan.

The Wild modular system lets you get the maximum out of each instrument and accessory. It ensures instrument compatibility over many product generations. That is your guarantee of maximum convenience for future surveys.

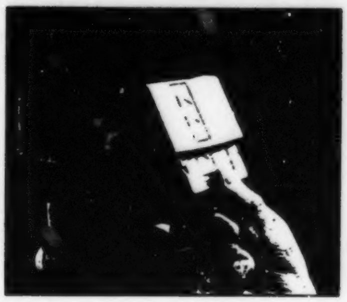
At minimum investment cost, your existing equipment benefits from state-of-art technology. Because modularity lets you customize the equipment to your jobs in field and office, it increases your productivity and profits. Wild modular hardware and software compatibility allows you to keep your equipment abreast of the dynamic changes that are happening to modern surveying.

With or without the coordinate-geometry functions built into Wild theodolites, the REC module closes the ring of automation. Measuring, recording, analysis, and restitution all become parts of a single, continuous process.

Ask your Leica distributor for details.

WILD LEITZ ERNEST IGLDESIGN

Record

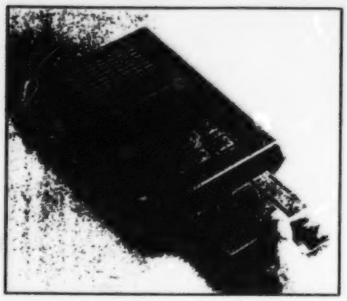


Wild GRM10 REC module, the plug-in memory

The REC module is an easy-to-use, dependable data-storage unit. Simply insert it in an electronic Wild theodolite or total station. The Wild GRM10 is the most economic way of recording survey data and gives you unlimited storage capacity.

Each REC module can record 500 data blocks and takes only a couple of seconds to exchange. Small, mailable, designed for field use, the GRM10 weighs just 70 g (2½ oz).

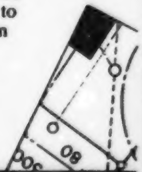
To store data in the GRM10 and call them up at any time for display on the theodolite, simply touch a key. For automatic data transfer from the REC module to a computer or printer, or from a computer to the REC module, use a GIF10 or GIF12 interface.

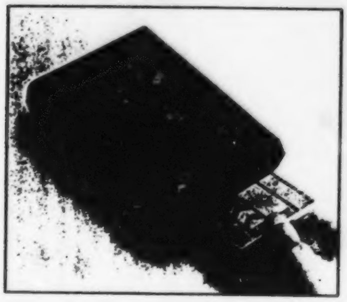


Wild GIF10 universal data reader

The Wild GIF10 is a universal interface for use between a REC module and the RS232 port on your computer, and with a printer, modem, or other peripheral equipment. The GIF10 is powered by mains supply or battery, and has a keyboard and display.

You can use it with or without a computer to call up and display or delete data stored on the REC module. And it allows you to copy data to other media or output them on a printer.





Wild GIF12 data reader for personal computers

For the owner of a personal computer, the low-cost Wild GIF12 is the economic solution. With no keyboard or display, this data reader is the ideal interface for on-line data transfer between the REC module and an IBM PC or compatible computer which runs under MS-DOS (from version 2.11). You can also use the Wild GIF12 for loading data into the REC module.

The necessary software is supplied free of charge with each instrument.

3.

Analysis

Data acquisition and further processing . . .

Surveyors with an eye to the future appreciate the numerous advantages of the modular Wild system.

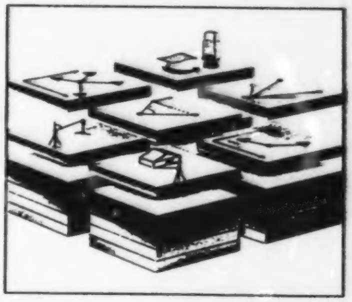
Back at the office, it gives them quick access to the field data stored on the REC module, for reliable, error-free analysis, restitution, and further processing.

4.

Documentation

. . . all the way to the finished plan

The clear software structure is ideal for graphic output of processed field data. You can call up the data selectively and readily define them for output on a plotter.

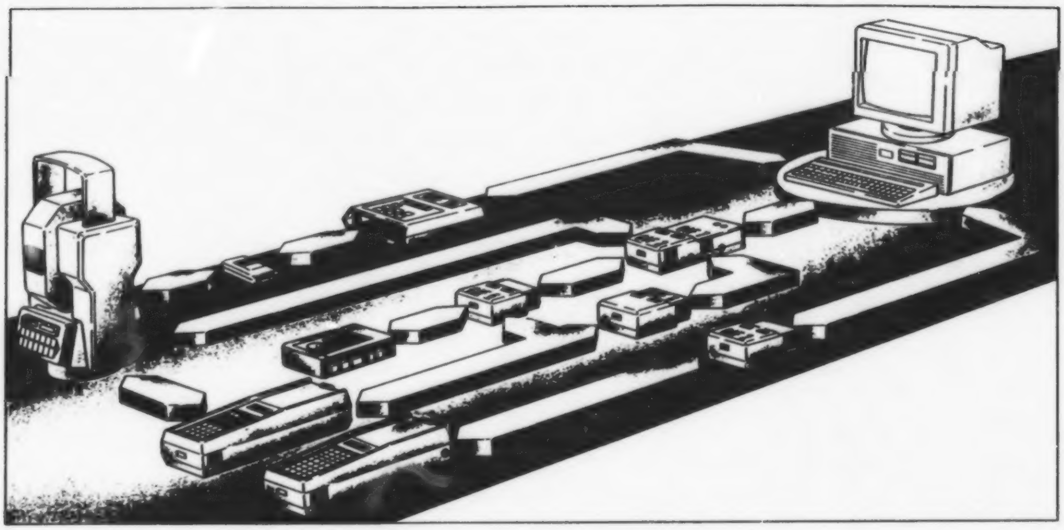


Unique range of software

The modular Wild system includes a comprehensive, flexible range of software.

In the electronic Wild T1600, T2002, and T3000 theodolites, and the TC1600 total station, you can access integrated coordinate-geometry functions via the REC module. These include height transfer, coordinate input, horizontal orientation, setting-out, computation of mean values, and other time-saving functions.

Wild modular recording system



Technical data

GRM10 REC module

Memory	16kbyte CMOS, capacity about 500 data blocks, data security 10 years
Data format	free, as for GRE4n and GRE4a
Environmental range	−20° C to +50° C (−4° F to −122° F), splash-proof
Dimensions, weight	74 mm x 60 mm x 10 mm (3" x 2½" x ½"), 70 g (2½ oz)
Power supply	from theodolite, no cables
Compatibility	current and future Wild systems
Mailable	

GIF12 data reader

Interface	• IBM PC Parallel or compatible computer • Slot for GRM10
Power supply	via interface from PC, or 9V internal battery
Working temperature	5° C to 40° C (41° F to 104° F)
Dimensions, weight	180 mm x 130 mm x 40 mm. (7¼" x 5" x 2½"), 340 g (12 oz)

GIF10 data reader

Interface	• RS232C, 25-pin female Cannon plug • Slot for GRM10
Display	alphanumeric LCD, 2 lines of 16 characters each
Keyboard	7 keys
Functions	• Send to computer • Store on REC module • Display • Delete • Copy
Working temperature	5° C to 40° C (41° F to 104° F)
Power supply	110 V−250 V AC mains, or 9V internal battery (about 12h operating life)
Dimensions, weight	180 mm x 130 mm x 40 mm (7¼" x 5" x 2½"), 610 g (21½ oz)

Illustrations, descriptions, and technical data are not binding and may be changed without notice.

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Telex 881222 wi ch

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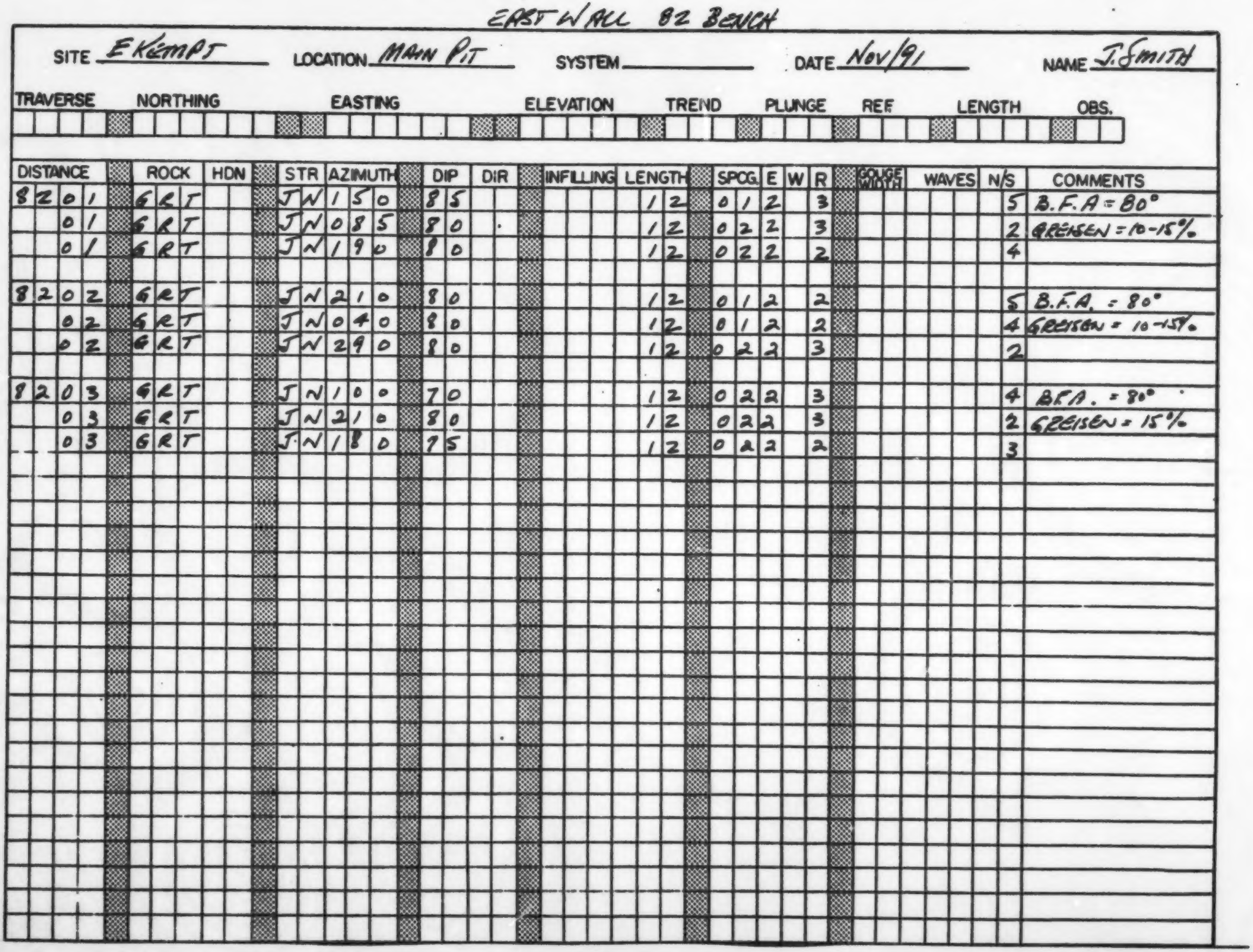
Never before has surveying and data recording been as simple as this

APPENDIX 4

OUTLINE OF GEOTECHNICAL MAPPING PROGRAM
AND DISTRIBUTION OF MAPPING STATIONS

Geotechnical Mapping Program

1. Map all accessible bench faces.
2. Mapping stations should be about 30 m apart on each bench.
3. Mark each mapping station on a 1:1000 pit plan and paint the station number on the bench face at each location. Have all the mapping stations surveyed and provide a plan of the plotted stations.
4. Carry out all geotechnical mapping as per the mapping manual and our field discussions.
5. Plot location and orientation of (1) sediment/granite contact and (2) any "major structures" (such as the fault which apparently runs down the centre of the pit) on a pit plan.
6. On the east wall, make a separate database of all very long structures that can be traced for at least three benches.
7. If possible, at every mapping station, measure the bench face angle and mark it in the comments column.
8. At a few locations, try and work out a relative age relationship between the various joint sets.
9. If any particular joint set appears to completely control or form the bench face (as in some areas of the metasediments), note with an asterisk in the comments column.
10. When finished mapping, send 1:1000 plan and all mapping sheets to Vancouver. I will also need 1:2000 plans of the existing pit and proposed ultimate pit.



EAST WALL 82 BENCH

SITE EKEMPT LOCATION MAIN PIT SYSTEM ______ DATE NOV/91 NAME J. SMITH

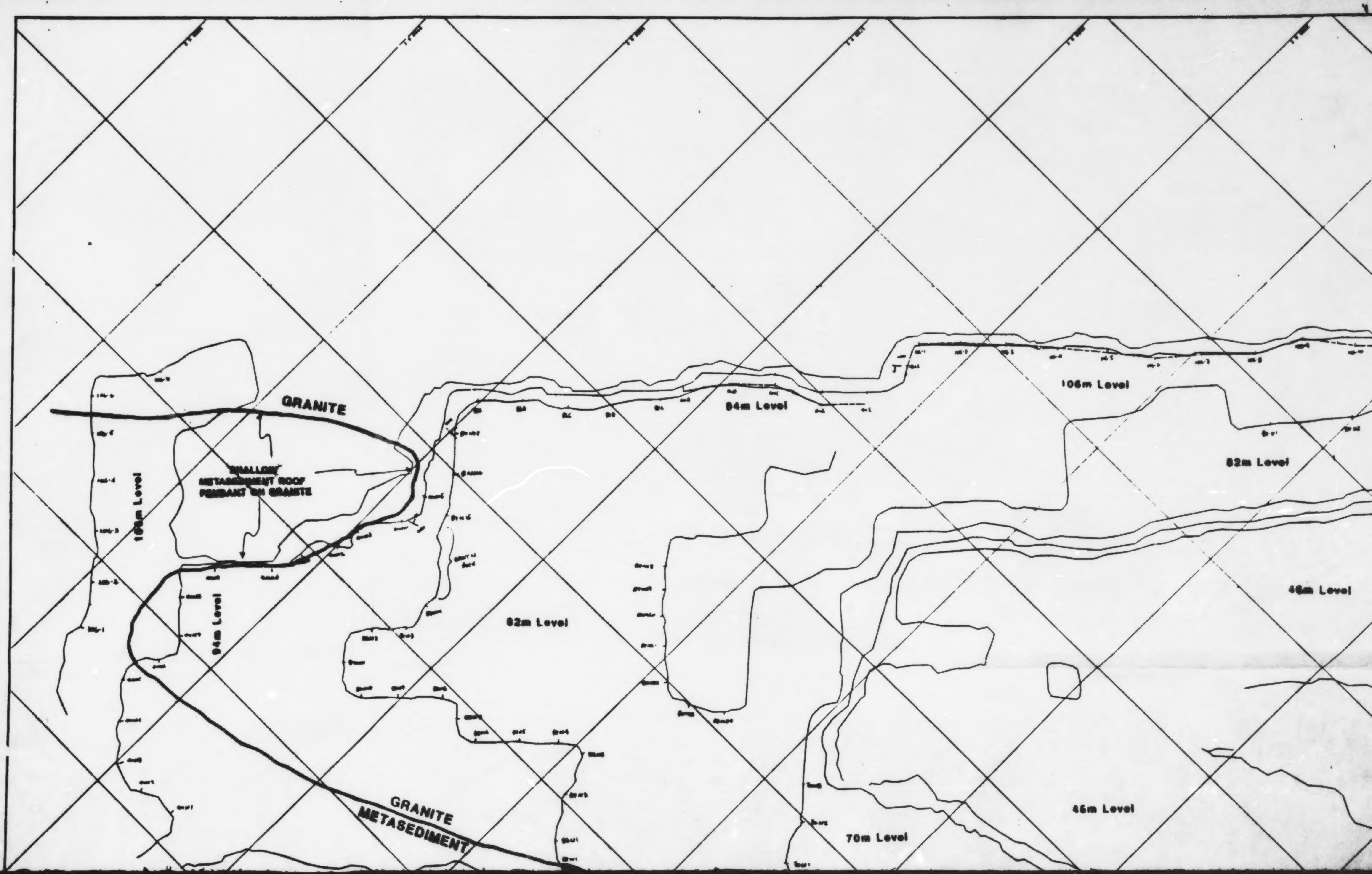
TRAVERSE	NORTHING	EASTING	ELEVATION	TREND	PLUNGE	REF.	LENGTH	OBS.

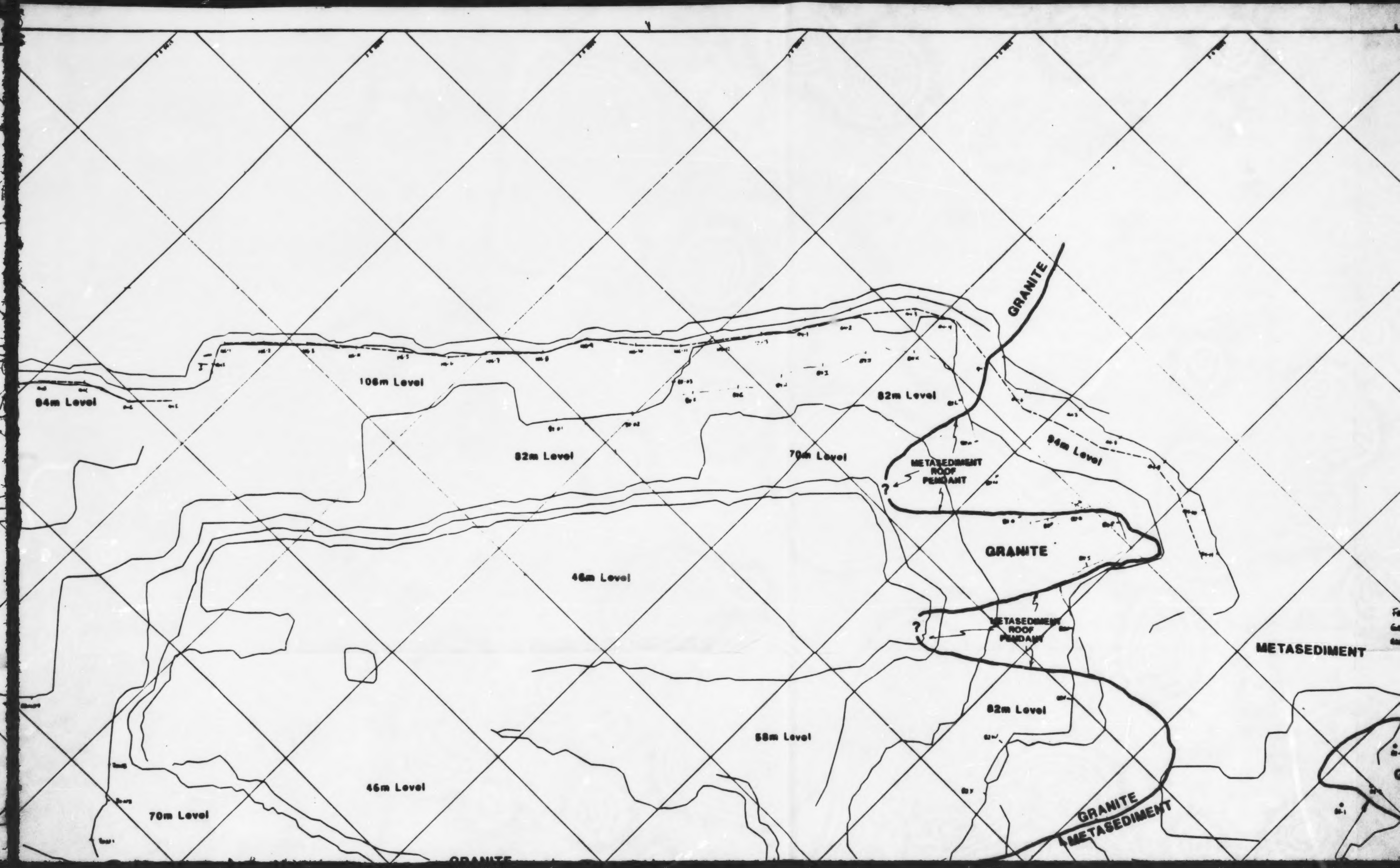
DISTANCE	ROCK	HDN	STR	AZIMUTH	DIP	DIR	INFILLING	LENGTH	SPCG.	E	W	R	GOUGE WIDTH	WAVES	N/S	COMMENTS
8201	GRT		JN	150	85			12	01	2		3			5	B.F.A = 80°
01	GRT		JN	085	80			12	02	2		3			2	GREISEN = 10-15%
01	GRT		JN	190	80			12	02	2		2			4	
8202	GRT		JN	210	80			12	01	2		2			5	B.F.A. = 80°
02	GRT		JN	040	80			12	01	2		2			4	GREISEN = 10-15%
02	GRT		JN	290	80			12	02	2		3			2	
8203	GRT		JN	100	70			12	02	2		3			4	B.F.A. = 80°
03	GRT		JN	210	80			12	02	2		3			2	GREISEN = 15%
03	GRT		JN	180	75			12	02	2		2			3	

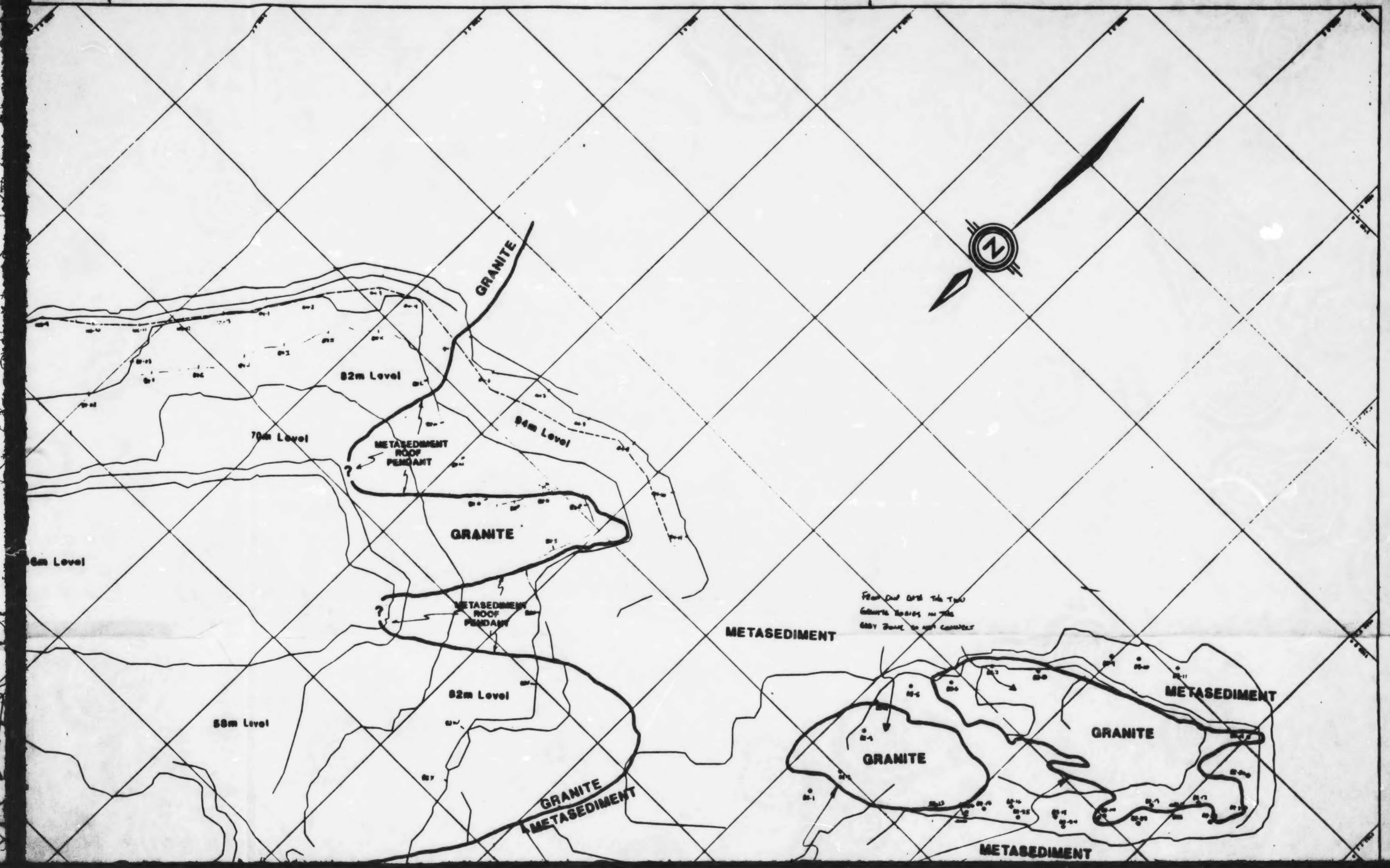
Fig. 1: Standard data sheet for recording geological mapping data.

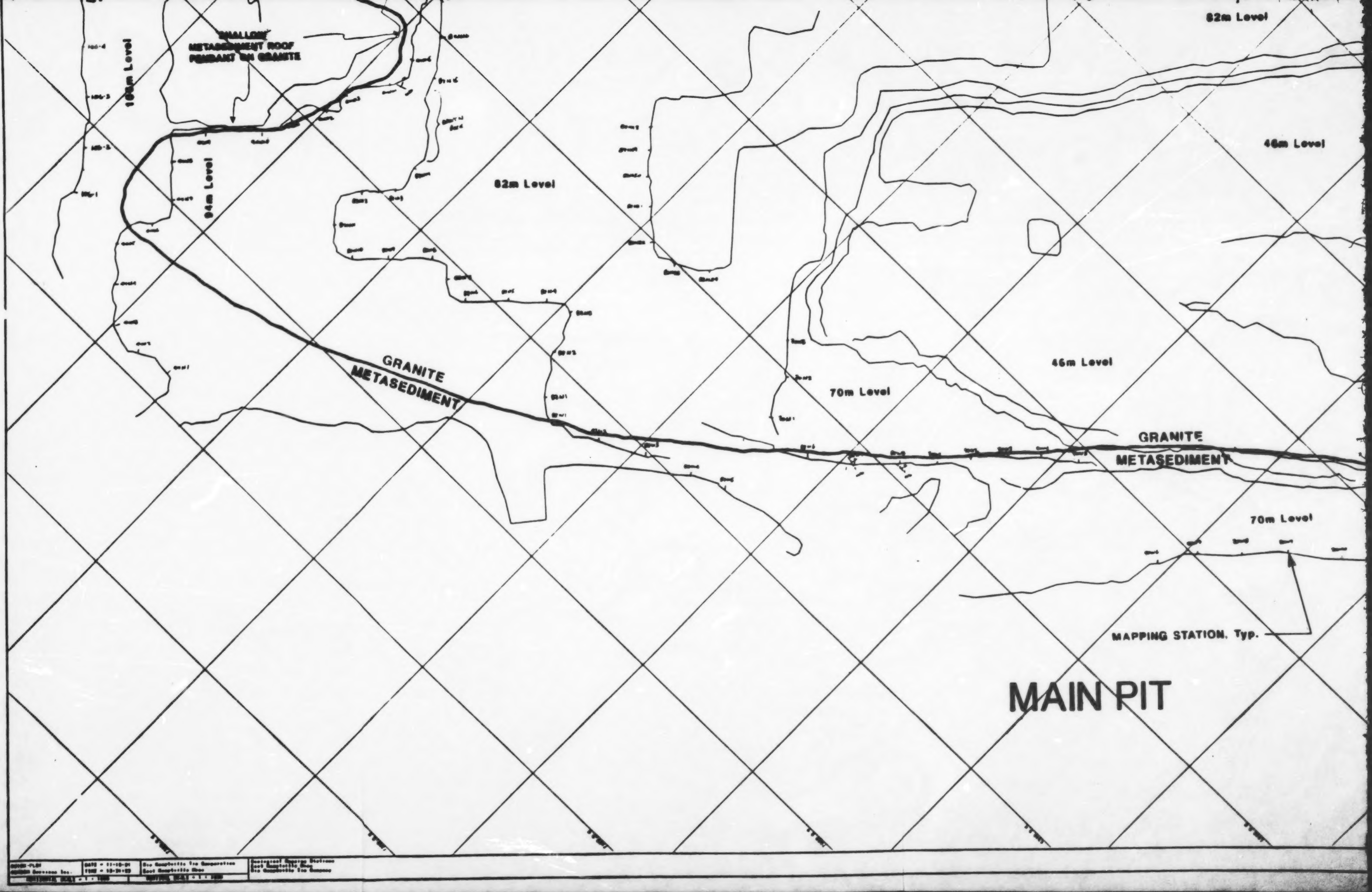
Distribution of Mapping Stations

		Main Pit	Baby Zone
Bench	106	20	
	94	32	26
	82	59	
	70	19	
Totals		130	26

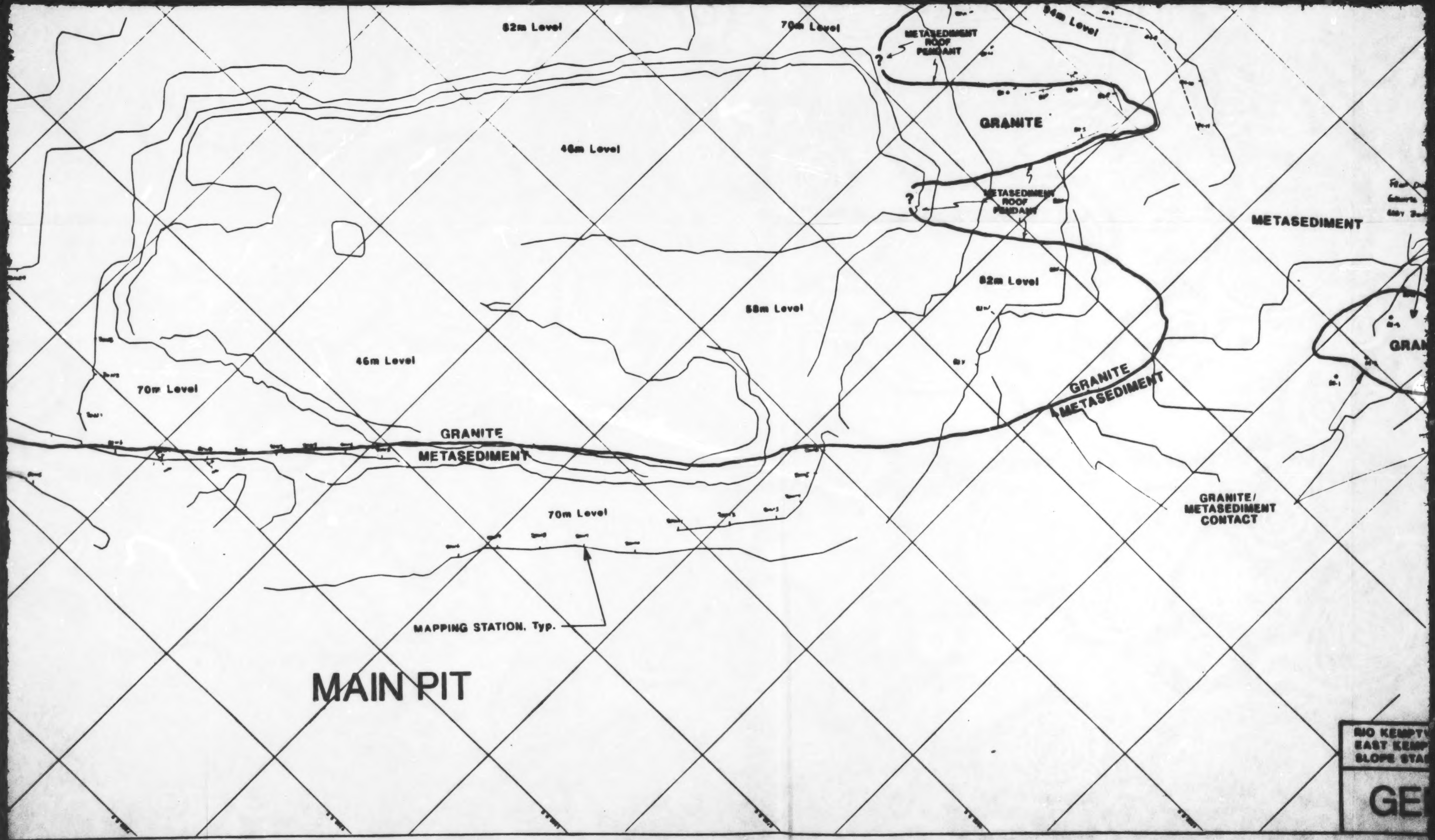

GRANITE
"SHALLOW" METASEDIMENT ROOF PENDANT ON GRANITE
106m Level
94m Level
82m Level
106m Level
94m Level
82m Level
46m Level
70m Level
46m Level
GRANITE
METASEDIMENT


GRANITE
106m Level
94m Level
82m Level
82m Level
70m Level
94m Level
METASEDIMENT
ROOF
PENDANT
?
GRANITE
46m Level
?
METASEDIMENT
ROOF
PENDANT
METASEDIMENT
82m Level
58m Level
46m Level
70m Level
GRANITE
METASEDIMENT
GRANITE


GRANITE
82m Level
94m Level
70m Level
METASEDIMENT ROOF PENDANT
?
GRANITE
6m Level
?
METASEDIMENT ROOF PENDANT
METASEDIMENT
82m Level
58m Level
GRANITE
METASEDIMENT
N
FROM DDH DATA THE TWO GRANITE BODIES IN THE 6601 ZONE DO NOT CONNECT
METASEDIMENT
GRANITE
GRANITE
METASEDIMENT


82m Level
"SHALLOW" METASEDIMENT ROOF PENDANT ON GRANITE
106m Level
94m Level
82m Level
46m Level
46m Level
70m Level
GRANITE
METASEDIMENT
GRANITE
METASEDIMENT
70m Level
MAPPING STATION, Typ.

MAIN PIT



RIO KEMPTV
EAST KEMP
SLOPE STA

GE

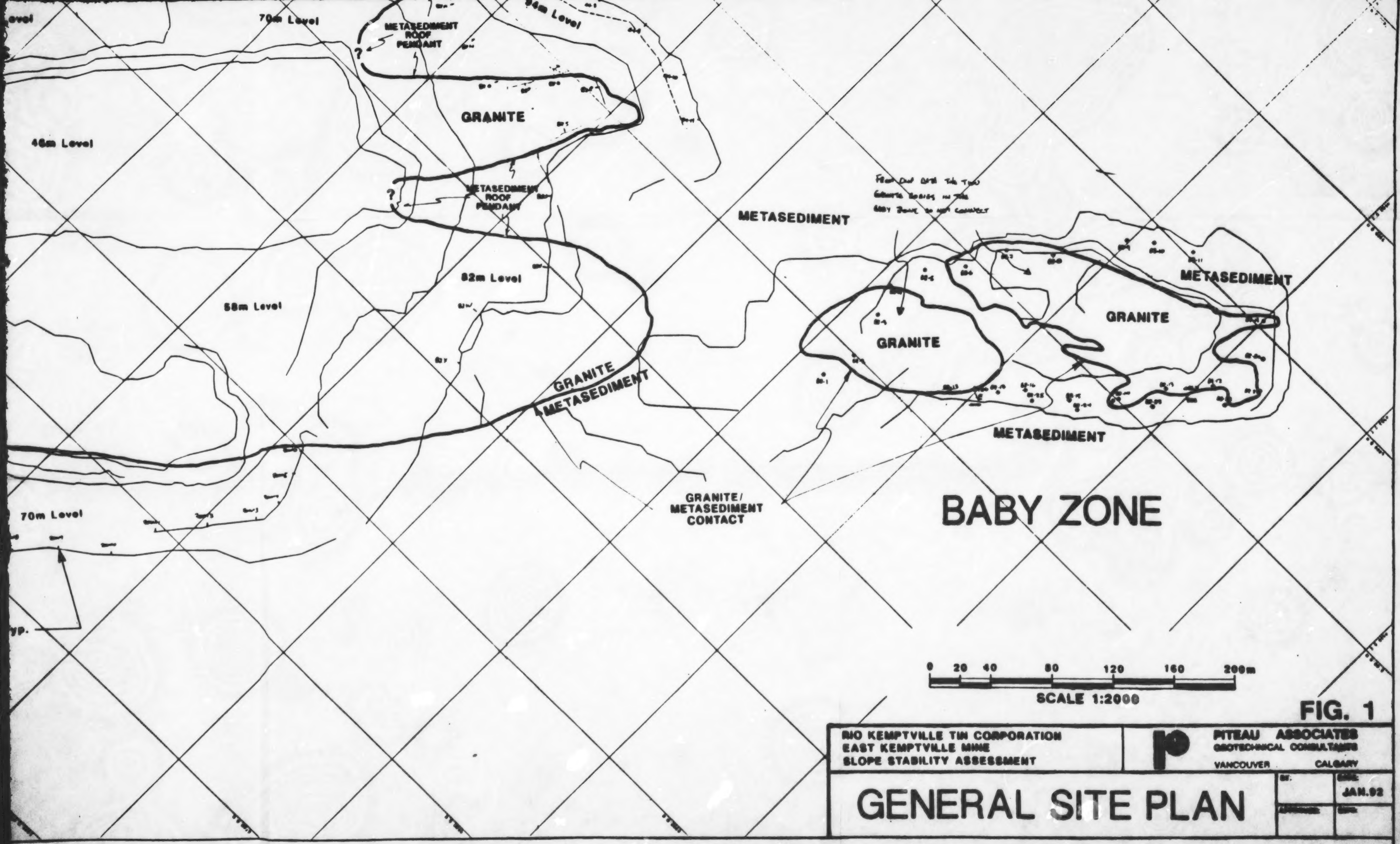


FIG. 1

RIO KEMPTVILLE TIN CORPORATION
EAST KEMPTVILLE MINE
SLOPE STABILITY ASSESSMENT

PITEAU ASSOCIATES
GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

GENERAL SITE PLAN

BY:
DATE: JAN.92
APPROVED:
DATE: